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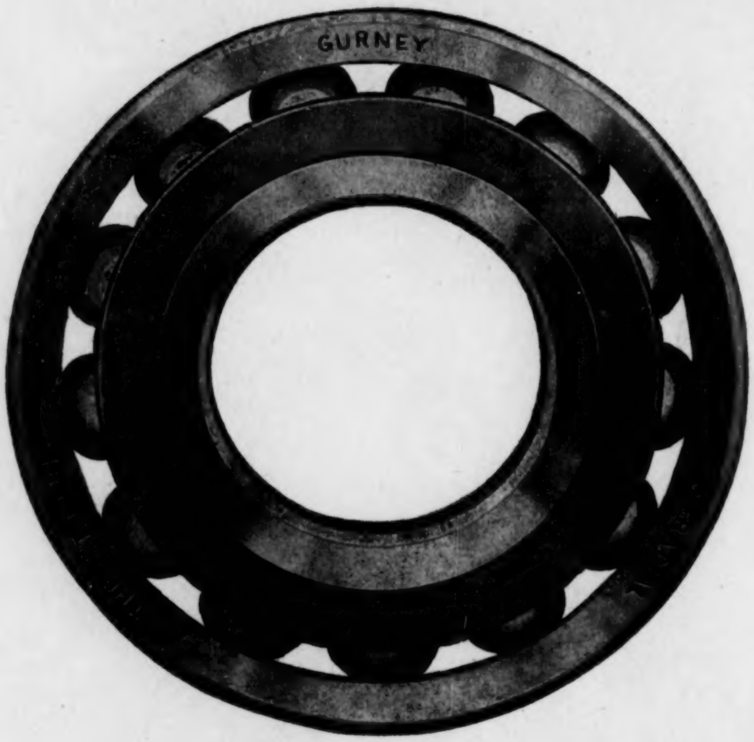

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The Right Man in the Right Place in the Army

By LT.-COL. JOHN J. SWAN,[1] U. S. A., WASHINGTON, D. C.

The Committee on Classification of Personnel in the Army, Adjutant General's Department, Washington, D. C., has recently arranged an exhibit to show how the army brings the job and the man together, and how the methods thus employed can be applied with profit to industrial management. The exhibit, which consists chiefly of charts and photographs, has already visited a number of cities, and has been received with great enthusiasm. The address abstracted below was delivered at a meeting of the New York Section of The American Society of Mechanical Engineers, on February 24, 1919, and will afford those who have not been able to visit the exhibit an opportunity to acquaint themselves with this interesting and important phase of the Army's work.

THE organization of a modern army covers nearly every field of human endeavor, and one is therefore not surprised to learn that even now vague ideas exist regarding the purpose and duties of many of the Government's war-time departments. In order that the work of the Personnel Department of the Army might be properly understood and appreciated, the Committee on Classification of Personnel, under the Adjutant General and with his authority, has prepared a special exhibit, which is arranged to acquaint one with the various steps involved in "making a soldier," from his arrival at the camp to the time when he begins training; and again through the steps of assignment, transfer, and shipment from the camp to service overseas. The magnitude of this work can perhaps be judged from the statement that approximately 3,700,000 men had to be interviewed, enrolled, equipped and assigned.

The men coming into the camps represented every conceivable type—men with special technical education, skilled tradesmen, and workers of all degrees of ability. The necessity for conserving the skilled workmen early became apparent to the Personnel Department, for it was found that many specialists and skilled tradesmen of certain types were rare. Of 425,000 men received in the draft up to December 15, 1917, reduced to the basis of 10,000 white and averaged over the entire country, it was found that there were only 50 bakers, 90 blacksmiths, 8 bridge carpenters, 90 butchers, 190 cooks, 150 electricians, 8 farriers and a small representation of the other trades essential to the operation of the Army. These figures are based on the statements of the men themselves as interviewed by the Personnel Officers, but when the men claiming these trade abilities were examined or tested by the system employed by the Personnel Department it was found that only 6 per cent were experts, while 24 per cent were journeymen, 40 per cent apprentices, and 30 per cent without any experience whatsoever.

These figures thus bring out very forcefully the vital necessity of the system employed in the Army to detect such skilled men and place them in organizations where their skill was required. Without this system skilled men of all kinds would have been consumed in the early days and none left for subsequent Army extension; industry would also have been robbed, and to such an extent that the flow of munitions could not have been maintained.

Methods of Classification

The process of "making a soldier" is illustrated diagrammatically in Fig. 1. This is a routing diagram showing the stages in enrolling the recruits and transforming them into fully equipped soldiers. The black line is the path of all the men. The first step is the receiving and checking of draft papers, and the next an interview to obtain the recruit's record for his Qualification Card. This card, shown in Fig. 2, was made out for every man in the Army. The third step is the Oral Trade Test to check the statements of those claiming trade ability, and this is followed by the checking and sterilizing of clothing for storage, pending final acceptance or rejection, and a shower bath as preparation for the medical examination. The civilian clothing of men accepted was sent home or given to the Red Cross, in accordance with the desires of the man, and the clothing of those discharged was transferred to the Discharge Section of the building, to be ready for the men as they passed out at the far end.

The actual medical examination requires several rooms, the first being for dental and orthopedic examinations, and also for obtaining the height and the weight; and the next for examinations for skin afflictions, mobility of joints and other details. A third room is necessary for psychiatric examinations or those to check the mental alertness or intelligence; then follow in order the genito-urinary, primary tuberculosis, heart and circulation, nose, ear and throat, and eye examinations.

In the medical examinations up to this point, men with varying degrees of perfection have been found, and on leaving the eye room the stream is split, those having been found physically fit for any class of military service continuing along the path of the heavy line, and those giving evidence of any fundamental defects following the path of the light line for a secondary review. After this second examination these men are placed in one of two classes, Class B, those who have "remediable defects" requiring hospital treatment, and those known as Class D men, who are unquestionably unfit for any class of military service. These two classes follow the light line through the Development Battalion Review Board room and the Discharge Section, through the dressing room where they receive back their civilian clothes, and finally they are given any pay to which they may be entitled, and transportation.

Men classified by the Camp Surgeon as Class C-1 and C-2 men, and illiterates, are also passed through the Development Battalion Review Board room where a special group of medical and personnel experts give each case careful consideration, and then they go back into the line of accepted men, indicated, however, as men for "limited service" only, and for assignment to Development Battalions. All men then pass through the finger-print, scars and body-mark room, and next to the Quartermaster Section, where they are measured for clothing and shoes; then along the counter where they receive underclothing, outer clothing and other equipment and are permitted to dress. Next they pass forward to the record room where the equipment issued to them is recorded, and then on through the mustering-in room where they are interviewed for service records. In the next section applications and instructions with regard to insurance and allotments are prepared, and this is followed by an inspection of all the various papers accumulated by each man in his passage through the system, to see that they are correct and complete. Finally the men are vaccinated and inoculated and then definitely assigned to a company or organization as soldiers ready to begin military training.

As already mentioned, Fig. 2 illustrates the front and reverse side of the soldier's Qualification Card used in registering information in regard to enlisted men. This card was one of the credentials of every man, and moved with him wherever he went. The card gives the essential facts in connection with each man; his occupation, trade skill, previous experience, former employer, nativity, citizenship, schooling, linguistic ability, mental capacity, physical capacity, leadership ability, military experience, and kind of service preferred, together with subsequent military assignments. These cards are not filled out by the recruits themselves but by an interviewer who obtains from each man the information required. The card is also used to classify the men under certain standard trade-name headings or occupations essential or desirable within the Army, as it records the man's prime occupation, secondary and tertiary occupations, and length of time engaged in each.

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When the card is completely filled out the interviewer places a tab on the top of the card above the line of numbers. These numbers indicate the line in which the man can be classed. If he is "skilled" they are marked by green tabs, and if "partially skilled" or apprentice, by an orange tab.

The cards thus tabbed enable a quick selection of men of special ability, and also permit a rapid compilation of data for

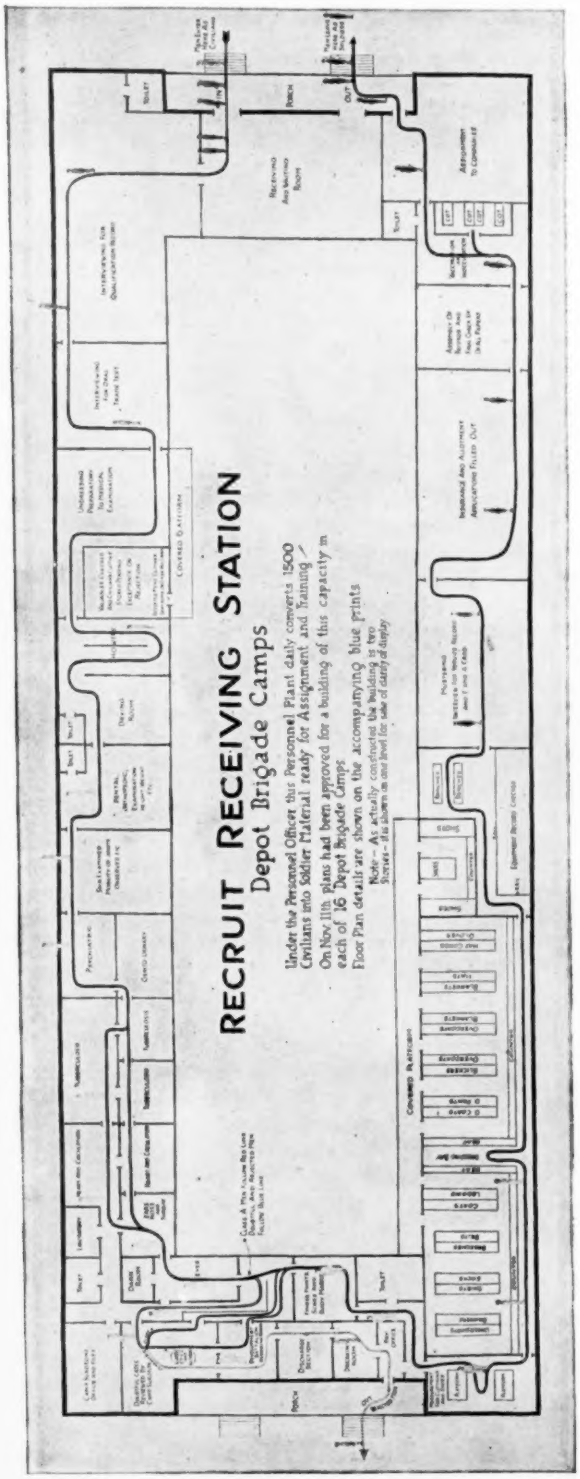

Fig. 1 Recruit Receiving Station

reports to the Central Office in Washington regarding the total numbers of men of various trade or professional ability within the camp, and available for transfer to other units or organizations.

At regular intervals a detailed tally of the cards of all unassigned drafted recruits in the camp was made and a report of totals of men under the standard occupational headings, and whether journeymen or apprentice, was forwarded to the Central Personnel Office in Washington.

Fig. 3 is a page from the Army Trade Specifications, and shows three of the 714 occupations in the Army classification system. The preparation of this list involved a very thorough detailed study of all of the organizations within the entire Army and an analysis of all of the trades or types of men required in such organizations. It represents the standard which was employed throughout the Army to designate trades and occupations. In other words, the mere statement that a man is a blacksmith is not sufficient, as the meaning of this term differs in different localities and in different industries. In the Army system, the general heading "Blacksmith" is required as a group heading and it is subdivided to cover various types of blacksmiths, and each of these types has a special name and a symbol. By the use of these specifications it is possible for any one desiring to requisition tradesmen to determine just what type of man is desired by examination of the specifications and then call for such man, using the standard name and symbol. The occupational list and trade specifications thus form the common language employed throughout the entire Army organization, and were the basis of the personnel classification employed.

The Clearance or Allotment Section of the Central Personnel Office was in Washington, and each week this office received an Occupational Report from all camps or draft receiving depots. The data on these separate reports were posted or consolidated in what were known as Supply Books under the headings of locations and trades. The Supply Books, therefore, gave the total supply of skilled men of all kinds in the camps and depots of the country.

The demand for skilled men came from the technical staff corps and the divisions being formed, and upon the receipt of a requisition by the Allotment Section the requirements stated thereon were examined with regard to the nearest camps or available supply of men as shown by the Supply Books, and an Allotment Sheet made out in which was stated the camps from which the supply was to be filled, and the number and kinds of men to come from each. From this Allotment Sheet a series of formal orders was made out, one for each camp or depot. With the completion of the Unit Allotment Sheet, which is presumed to cover all details of the requisition, separate Adjutant General orders were made out for each of the camps from which men were to be drawn. The Personnel Officer at the camps receiving "through channels" the regular order for transfer proceeded to issue the necessary camp orders and made out a "report of transfer," a copy of which was returned to the Allotment Section, so that actual shipment could be checked against its order.

All of the foregoing sounds exceedingly simple, but it requires great care and accuracy in order that mistakes be avoided and it is in this connection, and particularly because of the close coöperation between the Central Personnel Office in Washington and the Personnel Organization in the various camps, that it was possible to reduce the time of organization of a division from the nine months required in the early stages to three months toward the end, and also to effect more thorough organization in the shorter time.

Approximately 3,700,000 men of all sorts were thus carded and classified and requisitions were received and orders issued for the disposal of approximately 1,200,000 men, distributed as follows:

General Service	865,058
General Service—Colored	180,412
Limited Service—White	59,294
Army Schools, White and Colored	89,058
Special Draft (P. M. G.)	56,009
Induction Authorized	161,663

The method of recording information with regard to officers was, broadly speaking, exactly the same as in the case of enlisted men. When it is considered that there were approximately 195,000 officers in the Army at the close of the war, some slight idea can be gained of the necessity of being able instantly to locate or select officers of various experiences and abilities in

order to organize or reorganize infantry or technical units. In the case of officers, however, inasmuch as considerable additional information was required over that for enlisted men, the card was made larger. On these cards were recorded in a systematic manner and uniformly, history, education, experience and all other data to afford a clear picture of each individual officer. The original card was filed with headquarters of the particular unit with which the officer was connected. A duplicate card was filed in the Central Personnel Office at Washington or at headquarters overseas, and as officers were ordered overseas copies of the cards went with them in order that the system might operate efficiently with the fighting forces.

Rating of Officers

In the past, officers were selected or promoted by seniority or on the basis of personal judgment of some superior. When the Army was small and there were relatively few officers, this system, though not ideal, was used with a fair degree of satisfaction. However, with the rapid inflow of new material necessary to meet the tremendous expansion of the Army, it was impossible to employ such a system, and it became evident that some standard method must be devised which would insure accuracy of results and impartial treatment to all.

To meet this condition the Central Personnel Organization at Washington put into effect a Rating System devised by Walter Dill Scott, Director of the Committee on Classification of Personnel in the Army. Starting with the Officers' Training Schools, this system was put into effect step by step until now it covers the entire Army and is the standard system employed for selecting and promoting officers here and overseas.

Briefly, the system is based on giving to each officer a rating which is made by his immediate superior and which rating is determined quarterly so that the improvement or change in the officer's work or ability can be credited at frequent intervals.

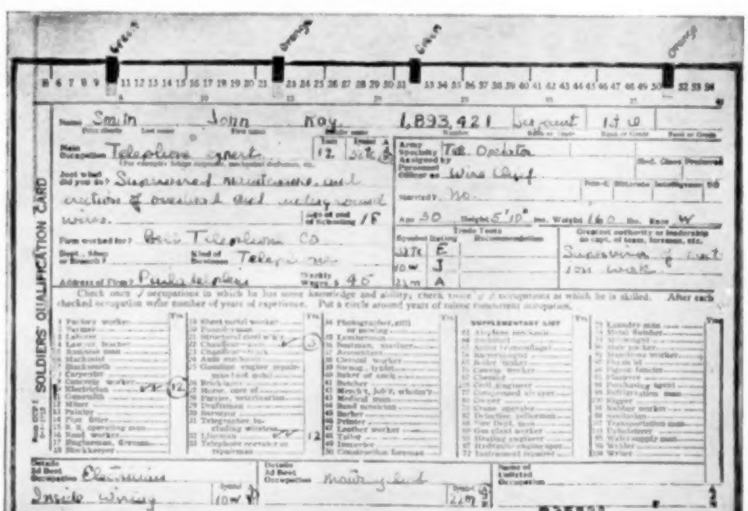

Fig. 2a Details of Soldiers' Qualification Card (Front)

The system consists of each rating officer preparing for himself a scale of measurement in accordance with a simple yet effective method which can be understood by all and is universally applicable. This scale considers separately the essential qualifications of the officer, such as physical qualities, intelligence, leadership, personal qualities and general value to the service, and the rating officer considers such officer whom he has to rate in the light of these qualifications one by one as contrasted with the officer on his scale.

In preparing his scale for rating any group of officers under his command, he thinks of the purely physical qualities of all officers of his own rank with whom he is acquainted and visualizes the physique, bearing, neatness, voice, and endurance of each, irrespective of any other qualities. Among all those he has in mind, some one will stand out preëminently and he writes down the name of this particular officer as highest. Another one will rank slightly lower, still another about average, another low, and finally one will be visualized as being lowest in the quality named.

In a like manner he then selects five officers on the basis of their intelligence, another five for their leadership, others for their personal qualities, and finally those whom he believes to be of value to the service.

The rating officer then has a scale under five general headings with five names under each heading ranged from highest to the lowest with purely arbitrary factors of value opposite each name. It should be noticed that in the preparation of this scale it makes no difference whether a general or first lieutenant has worked it out, for in the preparation of the scale any conscientious officer can do this who has considered essential qualities and has made up his scale ranging from highest to lowest of men of his own rank with whom he is personally familiar.

Fig. 2b Details of Soldiers' Qualification Card (Back)

In the application of the scale the reverse process is followed. If, say, a captain has to rate a number of lieutenants, he proceeds to take each and analyze him quality by quality, for the moment forgetful of all other elements of his make-up. For instance, he considers first his physical qualities, he compares him one by one with the various individuals whom he has listed in his scale. If he has the quality of the highest in the physical class, he credits that lieutenant with the highest factor; if comparable with the average man of the scale, he gives him the average factor; if lowest, the lowest factor. Having done this, he forgets completely the physical qualities and takes those of the next quality named in the scale and compares him one by one with the scale names.

In this way all officers are rated on the fine points in an orderly, logical and systematic manner, and as far as humanly possible prejudice or preference has been eliminated and the rating given each is comparable to officers of like rank no matter where or by whom rated. However, as a further safeguard the details and final rating in each case are checked by each rating officer's immediate superior.

The results obtained for October 1918 in the case of a number of large camps show that the rating officers have given average ratings of from 58 to 62, and this experience has shown to be about correct.

Psychological Tests

The results obtained through the use of various psychological tests adopted in the Army to check the intelligence or mental

alertness of men, both commissioned and enlisted, are most interesting and valuable. Some of these are shown in Fig. 4.

At the upper left side of the figure is shown a chart indicating the average intelligence of officers in the various arms of the service, the plain white indicating A and B intelligence rating, the shaded portion C+, and the black section those below C+. The chart is ranked in order of degree of A and B rating, C+, and below C+. It will be noticed that it grades Engineers at the top, with practically all A and B intelligence ratings, and a very small proportion of C+, increasing in the lower rating rather gradually, with the veterinary group at the bottom. In the latter the tests developed that of those tested about one-half were of A and B intelligence rating and one-half of C+ and below.

The lower chart on the left-hand side shows results obtained in testing the intelligence rating of men undergoing training in the Fourth Group of Officers' Training Corps. These are placed in order of highest intelligence, with Camp Lewis leading and Camp Wheeler at the bottom of the list at the time these tests were made.

The chart at the lower left center illustrates the utility of intelligence tests as applied to a group of Officers' Training Camps and Non-Commissioned Officers' Schools, the upper diagram being the summary of 1375 officer candidates. It will be noticed that the heavy vertical lines A, B, and C+ are practically all above the horizontal line, but indicate that almost without exception officer candidates having intelligence ratings of A, B, and C+ prove successful. In almost as nearly striking manner the lines C, C— and D, indicating men of lower intelligence ratings, extend below the horizontal line into the region of those who proved failures.

This chart indicates in a general way that, barring a few exceptions in a neutral zone, it would have been possible in the first instance to select candidates by some form of intelligence test, and thereby practically double the capacity of the training camps. The diagram in the lower half of the chart indicates in like manner the result obtained with the 1458 non-commissioned officers, and in this the same argument holds.

The chart at the lower right center indicates results of intelligence tests in connection with special groups, the upper diagram showing 465 promotions of various sorts, indicating that where men were "recommended for promotion" they were, to a very large extent, men of higher intelligence. The "assignment to special duty" in the case of 785 men tested, shows a similar result, although in this case the percentage of men of high intelligence is not so large. The lower line covers the test of 491 men who had been subjected to discipline for one reason or another. Here is strikingly shown the fact that low intelligence is a very serious factor; conversely, it would be assumed that with the increase of intelligence the number of disciplinary cases would decrease.

The chart at the upper right-hand side very clearly indicates the wide difference in the average intelligence of various companies making up the 319th Infantry Regiment. The height of the line for each company above the horizontal line varies from 3 to 30 per cent of men of A and B intelligence rating. The percentage of illiterates or foreigners below the line varies from 9 to 60 per cent. It will be noticed in Company A, the percentages of intelligence and illiteracy nearly balance. In Company C, however, there are only 3 per cent of the men of a high intelligence rating and 38 per cent low. It is seen from this that if a definite schedule for training had been prepared, calling for certain work to be accomplished in a definite period of time, and assuming company commanders to be of equal ability, it would be impossible for Company C to develop as far as Company E. The chart shows the importance of endeavoring to equalize the various companies in any organization, at least in the first instance. It is appreciated that when an organization gets into actual combat service, exigencies will arise which prevent carrying out any ideal system, but in the first instance, when organizations are being formed or built up and trained, such matters can receive attention.

The chart at the lower right-hand side affords a comparison of the enlisted personnel of the various arms in the 34th Division. In this division the Sanitary Detachment was first in the matter of intelligence, the Engineers being found further down the line.

B

FAMEK 7-fm **FORGING MACHINE OPERATOR**

DUTIES
1. Operation of standard types and various kinds and sizes of forging machines, such as bulldozes and hydraulic presses on general work.

QUALIFICATIONS
2. Should have thorough knowledge of rivet and bolt forging machines, screw, toggle and hydraulic presses for heading staybolts, forms, and all classes of press forgings of various materials.
Should have a practical knowledge of coal, gas, and oil types of forge furnace, and the proper heating of various material for forgings.
Must be able to set and adjust dies and maintain same and be able to turn out uniformly dimensioned product.

SUBSTITUTE OCCUPATIONS
3. Drop forge operator, press operator, heavy forge blacksmith, blacksmith.

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HADGA 7-he **HEAT TREATER**

DUTIES
1. Heat treatment in general of steel forgings, finished parts and castings.

QUALIFICATIONS
2. Must be thoroughly experienced in the heating and oil treatment of various grades of steel for annealing or toughening for any kind of work. Must be capable of annealing, quenching and drawing of all kinds of steel forgings and castings, either rough or after being machined. Must be capable of judging temperature by the eye, and familiar with the use of pyrometers.
Must thoroughly understand the construction and operation of standard types of coke, oil, gas or electric furnace equipment, and quenching tanks, and have a working knowledge of the metallurgy of steel, at least sufficient to know how it should be heated, treated and cooled, under instruction or by test.
Should have had similar experience in forge shop of any industrial plant.

SUBSTITUTE OCCUPATIONS
3. Annealer, heater, forge heater.

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HAEWS 7-h **HORSESHOER**

DUTIES
1. Shoeing horses and mules.

QUALIFICATIONS
2. Must be a practical horseshoer, capable of forging, shaping and punching horse or mule shoes from standard stock or bar material. Capable of removing shoes, paring and dressing hoofs, welding caulks, shaping shoes for correction of diseased or malformed feet.
Should have some veterinary knowledge, enabling him to care for and correct hoof troubles.
Must be able to handle and shoe unbroken horses under rough field conditions, and handle heavy horses and mules.
Should have some knowledge of blacksmithing and be able to make welds and do light blacksmith work.
Experienced as commercial horseshoer or as horseshoer in construction camp, or employee of company having considerable stock.

SUBSTITUTE OCCUPATIONS
3. Farrier, country blacksmith, blacksmith. 35928

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FIG. 3 PAGE OF ARMY TRADE SPECIFICATIONS

TRADE TESTS

In describing the Recruit Receiving Station, mention was made of Trade Tests to check the verbal statements of men claiming trade ability. A very interesting and important side of Personnel Work in the Army has been the development and introduction of these tests into the camps and depots receiving draft men. Owing to the diversity and number of trades encountered, a very thorough study was required in determining whether tests could be applied and if so what character of tests were necessary.

As a result three forms of Trade Tests were developed, sometimes applied singly and again two or all three used. The first of these is the "oral trade test," in which the candidate or recruit is asked a series of standardized questions which have been prepared with the greatest care to eliminate ambiguity and localisms or catch features. A trained interviewer or tester asks the questions exactly as printed and in accordance with simple but very definite rules, and the recruit answers to the best of his

ability. For the benefit of the tester, the correct answer, or several answers if more than one is possible, are given under the questions. If the recruit answers correctly he is given a maximum score. If his answer is partially correct in accordance with a definite schedule, he is given a partial score. After all of the questions have been answered and scored by the tester, the total is taken and compared with the rating scale, which scale gives the terms Novice, Apprentice, Journeyman and Expert within certain numerical limits. In other words, in the case of the tailor's test, a score of from 18 to 37, inclusive, would give the recruit a rating of Apprentice; 42 to 56, inclusive, Journeyman; and 59 and above, Expert.

The second form of the test is known as the "picture test," and employs pictures of certain essential tools or devices of the trade with which a man who has or can perform in the trade must be familiar. In this test a sheet of numbered pictures is given to the recruit and the tester holds a corresponding question sheet with questions and answers corresponding to the numbered pictures. The recruit must name the various tools or appliances and the tester scores up and gives a rating as in the former case.

Post 3 round a curve. The scorer then tells him to back up to Post 2. This little preliminary run indicates whether the recruit can drive a car at all, and gives evidence of sufficient ability to proceed with the remainder of the test. It also gives the man a familiarity with the throttle and gearing and "feel" of the particular machine to be tested. The scorer then instructs him to drive on to Post 4 and turn to the left and enter the S or reverse-curve section outlined by vertical post or stakes. He is instructed to drive through this S at whatever speed he regards as best and must not stop nor drive in a jerky, irregular manner, and he must not knock down any stakes. In emerging from the reverse curve to the large square he is required to drive close up and with his hood at the center of the board at station 5. The scorer then instructs him to back away and around the semi-circle section to the second square and continue backing until the tailboard is close up to and in the center of the board 6, which is supposed to represent a loading platform. He is then told to run forward close to Post 7, where he stops on the grade, and then start and run up to the top of the grade, turning around with no more than one backing and without stalling engine or grinding gears,

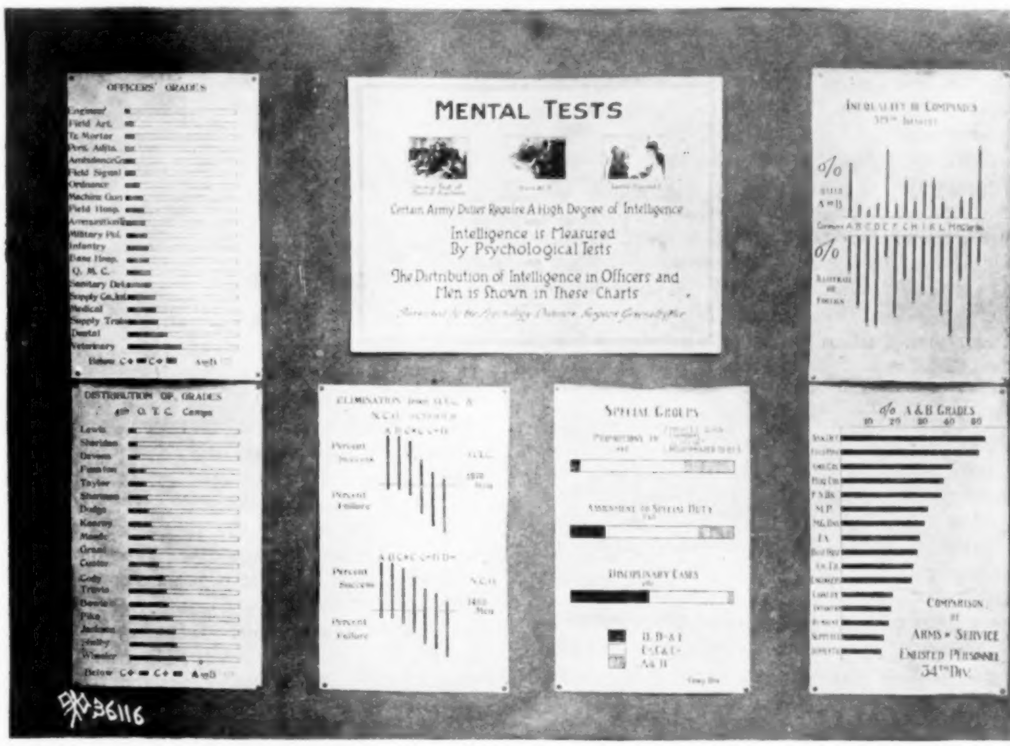

Fig. 4 Results of Psychological Tests

The third and last test consisted of an actual demonstration of the recruit's abilities. In the case of truck or auto drivers a course was laid out and each candidate was required to perform certain definite operations in a definite sequence and under identical conditions. If in doing this work he fails to perform all of the operations or does certain other things against which he is warned, he receives less than a perfect score. As in the former cases, totaling the scores gives a figure which enables the man to be rated as a Novice, Apprentice, Journeyman, or Expert.

In operation, the system is as follows: A recruit having claimed more or less ability as a truck driver when being interviewed in the first instance, is given an oral Trade Test, and provided he is classed by the interviewer as an apprentice, journeyman or expert in this, he is ordered to present himself at the performance-testing station at a definite time. On arrival at the testing station or truck course he takes command of a standard truck with a tester or scorer on the driver's seat with him to give instructions and score him for results.

The scorer instructs him to drive up to Post 1, which is the start of the test. He is then told to drive to Post 2 and on to

and then to run down the incline to the starting point. Careful instructions are given and all candidates are treated alike. It will be seen that the conditions of this test are very exacting, and it has been found that any man who gets a score of Journeyman or Expert in the test can subsequently make good under any conditions of service.

In accordance with the plans 92,550 truck drivers, 36,000 motorcycle drivers and 30,000 automobile drivers were needed overseas. These tests effected an enormous saving in maintenance and repairs because valuable transportation equipment was not turned over to inexperienced or incompetent men to be wrecked in a few hours, but was put in the hands of men proved to be skillful both in operation and care of their equipment.

The motorcyclist's test and the auto driver's test are in principle the same with varying details, inasmuch as conditions of practical operation vary somewhat from the truck driver's. It is interesting to note that these tests are at least in principle the rebirth of a system employed by the French in the very early days when automobiles were just beginning to appear in France, which was really the pioneer in automobile use. The municipal

authorities in Paris, and later in other continental cities, and still later in a few instances in the United States, employ practical tests of this sort before issuing licenses to drivers.

Carpenters were in great demand and to obtain these men the following test was employed: The recruit receives a blueprint or working drawing with dimensions and full instructions as to what is required in the finished piece. The material and tools are standard throughout and wherever the tests are conducted. The work to be performed consists in ripsawing a slab from one side of a 2-ft. piece of 2 x 4 rough scantling, in chopping with a carpenter's hatchet on one edge, planing of one face and edge and chiseling a smooth dovetail mortise at one end of the piece, all in accordance with the dimensions in the instruction print. The particular job has been prepared after extensive study with an idea of requiring a minimum amount of material and reasonable time, and yet to permit the fundamental operations required of a general carpenter, such as ripsawing, chopping, planing, chiseling, squaring, working to dimensions from a drawing or blue print, etc.

The tester is provided with a definite system of marking, scoring or crediting, so that each man is judged on what he has done in accordance with the standard system. This would give him the same rating regardless of where he performed his work, or by whom he was judged. In other words, in this test, and all of the trade tests, the fundamental criterion has been that the method of administering the test, scoring, and rating would be such that a man tested at any of the trade-test points and receiving a rating would have received exactly the same test at any of the other testing points.

Tests were also devised for linemen, patternmakers, inside house wiremen and blacksmiths, and since these trade tests were instituted about 250,000 soldiers have been tested.

These tests also emphasize the fact that it is not possible to accept a man's statement of his trade ability, for while the majority of men endeavor to tell the truth, each man's judgment of his own ability is nevertheless not comparable with any definite standard.

Briefly, the steps necessary in giving trade tests are:

1 The procurement of the necessary information
2 The preparation of questions on the basis of this information
3 The test of data and the revision of such questions or tasks
4 The second revision
5 The practical tryout to insure the value of the various questions for checking trade ability
6 A further analysis and check
7 The preparation of the tests in final form for practical use
8 The accumulation of further information bearing on results of the tests with the idea of improving them if it is thought necessary.

The foregoing is but a brief review of the general work which has been conducted by the Committee on Classification of Personnel in the Army. It is hoped that it will in some small way afford a clear and logical picture of classification as employed in the Army at the time the armistice was signed. It is sincerely hoped that this work, which was in a large degree responsible for the rapid and efficient organization of the Army, will not be permitted to lapse, but will be further perfected and carried forward, and as time goes on become a complete and permanent part of the Army Establishment.

Peat and Its Uses

Attention is called by the Department of the Interior, in a recent bulletin, to the vast undeveloped peat deposits in the United States, and to the many possible uses of peat. In northern Europe it is used for fuel and as the basis for many manufacturing industries. Gas, charcoal, coke, and a number of valuable by-products are produced from it. Owing to the scarcity of raw materials in Europe, peat and peat moss are also employed as substitutes for absorbent cotton in the preparation of surgical dressings, for wood, and for cotton and woolen cloth. In the United States peat is utilized chiefly as fertilizer and fertilizer filler, as stable litter, and as an absorbent for the uncrystallized residues of beet- and cane-sugar refineries in the manufacture of stock feed. The shortage of coal in the Eastern and Central States that began toward the end of 1917, however, has stimulated a wide interest in the potentialities of peat as a source of auxiliary fuel.

The following information concerning the features of peat as fuel has been gathered and published by the United States Geological Survey:

Peat in an undrained bog contains about 90 per cent of water, which must be reduced to 30 per cent before the peat can be used for fuel. By thoroughly draining the deposit, approximately 10 per cent of the original water contained in the peat may be eliminated, but the remainder which is held in the microscopic plant cells and minute intercellular spaces, cannot be reduced below 70 per cent without drying in the open air or in a heated chamber. No process of artificial drying has been developed as yet which can be considered as in any way one that is commercially feasible.

The value of a given deposit of peat as a source of fuel is dependent upon many factors, most important of which are degree of decomposition, heating value, and ash content. The maximum quantity of ash that is usually considered allowable in peat for commercial use has been placed at between 20 and 25 per cent, but if it exceeds 20 per cent of the total dry weight the peat is not considered worth the labor of production.

The comparative calorific value of peat and other fuels is given by the following figures:

	B.t.u.
Wood	5760
Air-dried cut peat	6840
Air-dried machine peat	7290
Lignite	7500
Bituminous coal	14000
Anthracite	13000

Cut peat is bulky, is easily crushed, and burns rapidly with considerable waste; it is superior to wood in heating value but is unfitted for commercial use. Machine peat is suitable for both domestic and industrial use. Powdered peat is well adapted for use under steam boilers with forced draft; for open grates this fuel is nearly ideal, and peat may be burned in the same stoves as coal and wood.

The machinery for the preparation of machine peat consists essentially of an excavator and a macerator. In principle and form the latest types of peat machines are similar to the pug mill or grinding machine for plastic clay. After being thoroughly macerated the peat is shaped into compact blocks as it comes from the machine. Machine peat which is allowed to dry slowly contracts into a dense mass covered by a gelatinous, skinlike substance called hydrocellulose. After the moisture has been reduced to about 25 per cent, this coating renders the machine peat impervious to water, even when immersed.

Powdered peat is prepared by reducing the moisture content to about 25 per cent and pulverizing the resulting material. It is said that when powdered peat is blown with compressed air into the furnace, ignition is almost instantaneous, the peat forming a gas which gives a uniform fire throughout the entire combustion chamber.

The value of peat, however, lies in its distillation rather than its combustion, and on these lines it could supersede wood in the production of acetic acid, methylated spirits of ammonia and tar. In the process of distillation peat requires larger retorts than coal, and of a design which facilitates the transmission of heat from the surface toward the center. Experiments have shown that revolving retorts produce the best results; the rotary movement of the retorts insures uniform carbonization in a short time and at a relatively low temperature.

To enable the gas arising from the carbonized peat to pass out of the retorts, the hollow shaft of each is perforated so as to provide a passage from the inside of the retort to a collecting chamber in the axis of the pivot and thence to the stills for fractional distillation. The distillation takes about forty minutes for retorts holding a ton of peat and making six revolutions per minute.

Electrical Measurement of Fluid Flow in Pipes

Theory and Development of a Device Embodying an Ammeter and Watt-hour Meter and in Which the Electric Current Flowing is Proportional to the Quantity of Fluid Passing Through the Pipe

By JACOB M. SPITZGLASS,[1] CHICAGO, ILL.

DESPITE the fact that the science of mechanical engineering is much older than that of electrical engineering, its methods of measurement are nevertheless in many respects much behind those afforded by the latter. A striking example of this is found in a comparison of the methods of measuring fluid motion in pipes and the flow of an electric current. The instrument used for the electric current is simple and direct-reading, and while there have been many excellent devices adopted for measuring the flow of fluids in pipes, it has been quite generally agreed that an instrument similar to the ammeter or wattmeter would be of great value.

Recently the writer had the privilege of experimenting with a flow-measuring device in which these instruments are applied. Measurement is accomplished by means of an electric current which is so regulated by the differential pressure of the flow that it represents the amount of fluid passing through the pipe.

The main features of the device are shown diagramatically in Fig. 1. The U-tube, partly filled with mercury, is made to balance the impact pressure of the flow in the pipe by the rise of mercury in the low-pressure side of the tube. The mercury column also forms a part of the electric circuit, as shown in the figure. This electric circuit contains a fixed external resistance R_1 in series with a variable internal resistance R_2, a constant electromotive force E, an ammeter A and a watt-hour meter W. In the contact chamber C, which forms the low-pressure side of the U-tube, there are a number of conductors of varying length placed above the mercury column, and as the mercury rises it makes contact with one conductor after another. The variable resistance R_2 is subdivided by these conductors into resistance steps corresponding to the varying length of the conductors, so that the rise and fall of the mercury column varies the amount of resistance and thereby regulates the amount of current passing through the circuit.

The basic principle of the device accordingly involves the laws governing the flow of fluids through pipes along with those governing the flow of an electric current. The problem of establishing the theoretical relation between these fundamental laws offered little difficulty because of the similarity between the units of flow measurement, such as pressure and velocity, and the units of electric measurement, such as voltage and current. On the other hand, the attempts to apply the theory to a working model were beset with numerous difficulties, and the obstacles that were overcome during the long period of experimental work presented many problems which are briefly dealt with in later paragraphs.

Units of Flow Measurement

The relation between the pressure and velocity of fluids in its simplest form is represented by the well-known equation

$$\frac{v^2}{2g}\delta = P_2 - P_1 = hw$$

or

$$v = \sqrt{\frac{2g(P_2 - P_1)}{\delta}} = \sqrt{2gw}\sqrt{\frac{h}{\delta}} \qquad [1]$$

where v and δ represent the velocity and density of the fluid; $(P_2 - P_1)$ the equivalent differential pressure; h the height and w the density of the liquid column balancing the differential pressure of the flow.

This differential pressure hw may be obtained, as shown in Fig. 2, either directly by balancing the difference between the dynamic and static sides of a pitot tube inserted in the line, or indirectly by balancing the difference between the high- and low-pressure sides of a venturi tube, nozzle tube or orifice plate. In the case of the pitot tube, the differential column in the U-tube represents the flow or motion existing at the given section of the line, but in the venturi tube, nozzle or orifice, the column obtained represents the *change* of motion produced by the artificial obstruction of the passage at the given section of the pipe.

In any case, however, the relation between the differential column thus obtained and the velocity of the fluid in the pipe may be represented by Equation [1], provided there is introduced

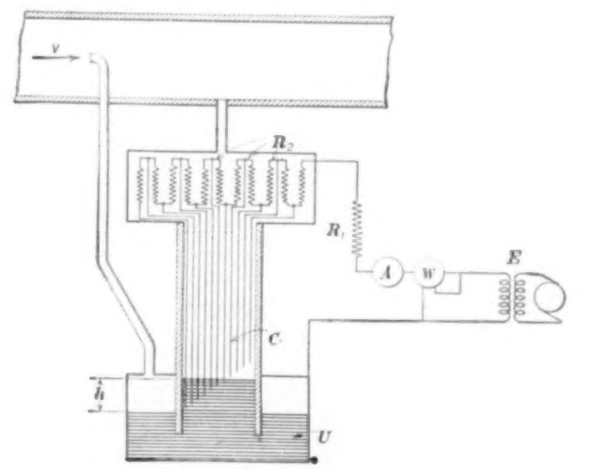

Fig. 1 Diagrammatic Sketch of Author's Electrical Device for Measuring Flow of Fluids in Pipes

the experimental coefficient derived for the given tube or orifice. Thus in general,

$$v = C\sqrt{2gw}\sqrt{\frac{h}{\delta}} \qquad [2]$$

The volume of the fluid Q passing per unit of time through an area A is given by the equation

$$Q = Av = AC\sqrt{2gw}\sqrt{\frac{h}{\delta}} \qquad [3]$$

the corresponding weight G per unit of time is

$$G = Q\delta = (A\sqrt{2gw})C\sqrt{h\delta} = KC\sqrt{h\delta} \qquad [4]$$

and the total weight S for a given period of time t is

$$S = Gt = KCt\sqrt{h\delta} \qquad [5]$$

Units of Electric Measurement

Having adopted the foregoing general equations for the flow of fluids, the corresponding electric measurements may be covered by the following definitions:

I = current in amperes flowing through the electric circuit of the measuring device. The instrument was designed so as to have one ampere represent the maximum capacity of the meter

E = electromotive force of the circuit. A uniform pressure of 40 volts was selected to represent the average density of the fluid measured

Wt = amount of electric energy expended in the circuit of the device in a period of time t

R = total resistance of the circuit in ohms.

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F = rate of flow in the pipe corresponding to the electric current in the circuit, or the ratio of G to I. F is the "indicating factor" of the flow meter.

T = total amount of flow or weight of fluid corresponding to the electric energy passed through the circuit. T is the ratio of S to W, and is designated as the "totalizing factor" of the flow meter.

Since by definition $FI = G$ and from Equation [5] $G = KC\sqrt{\delta}\sqrt{h}$, therefore $FI = KC\sqrt{\delta}\sqrt{h}$, or

$$I = \frac{KC}{F}\sqrt{\delta}\sqrt{h} \quad \ldots\ldots\ldots\ldots [6]$$

The value of K is constant for any given set of conditions as determined from Equation [4]. The value of C, depending upon the particular design of the tube or orifice, is also constant for any given case.

To find the value of F, let $I_{max.}$ be the current in amperes corresponding to the maximum capacity of the meter, $G_{max.}$, which in turn corresponds to the maximum differential column $h_{max.}$ From Equation [6]:

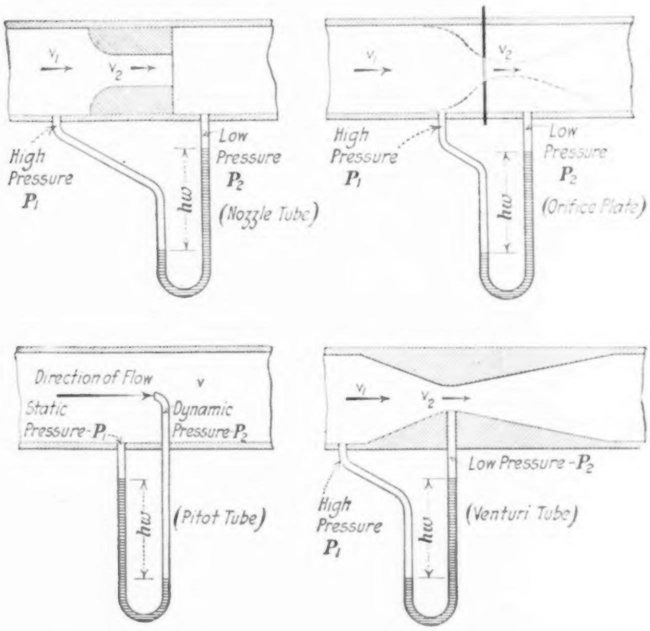


FIG. 2 METHODS OF DETERMINING VELOCITY PRESSURE

$$I_{max.} = \frac{KC}{F}\sqrt{\delta}\sqrt{h_{max.}} \quad \ldots\ldots\ldots\ldots [7]$$

whence

$$F = KC\sqrt{\delta}\frac{\sqrt{h_{max.}}}{I_{max.}} \quad \ldots\ldots\ldots\ldots [8]$$

and since $I_{max.}$ is equal to unity,

$$F = KC\sqrt{\delta}\sqrt{h_{max.}} \quad \ldots\ldots\ldots\ldots [9]$$

The quantity $\sqrt{h_{max.}}$ is called the characteristic or the scale of the given meter and it determines the capacity of the meter, depending upon the amount of differential column $h_{max.}$ which the meter is able to develop and record.

Combining Equations [6] and [9],

$$I = \sqrt{\frac{h}{h_{max.}}} \quad \ldots\ldots\ldots\ldots [10]$$

It is interesting to note that $h/h_{max.}$ represents the relative value of the differential column for a given rate of flow, and $100\ h/h_{max.}$ is the percentage variation of the head in any given meter. From Equation [10] it follows that in order to represent the amount of flow, the current I should be numerically equal to the square root of the relative height of the mercury column in the U-tube of the meter. From the same equation,

$$h = I^2 h_{max.} \quad \ldots\ldots\ldots\ldots [11]$$

That is, the height of the column for a given flow is numerically equal to the constant $h_{max.}$ times the square of the current flowing through the circuit.

From Ohm's law ($E = IR$) we obtain by substitution

$$R = E\sqrt{\frac{h_{max.}}{h}} \quad \ldots\ldots\ldots\ldots [12]$$

That is, the resistance R in the circuit should be numerically equal to the voltage divided by the square root of the relative height of the differential column.

It remains to determine the value of T, the "totalizing factor" of the instrument, or the ratio of S to W. Since $Wt = EIt$ and by definition $TWt = S = Gt = FIt$, therefore

$$T = \frac{F}{E} \quad \ldots\ldots\ldots\ldots [13]$$

That is, the totalizing factor of the meter is equal to the indicating factor divided by the voltage in the circuit.

Fig. 3 shows diagrammatically the relation of the units involved in the electric measurement of the flow. The parabolic curve to the right shows the variation of the current in the electric circuit representing the capacity of the flow and corresponding to the percentage variation in the differential column balancing the velocity pressure of the flow. This curve represents the solution of Equation [11]. The hyperbolic curve to the left of the diagram shows the relation between the current and the corresponding resistance at the given voltage of the electric circuit. The solution of Equation [12], or the relation of R to h, is obtained indirectly by following from a given value of R on the resistance curve to the corresponding value of h on the current-and-capacity curve.

It will be observed that the diagram does not include the first 10 per cent of the flow capacity inasmuch as this represents only 1 per cent of the differential column, which is as low as a practical device is able to measure with any degree of accuracy. This disadvantage, however, is offset by the fact that the scale of the flow meter can be so chosen that the desired measurements will fall within the active part of the scale.

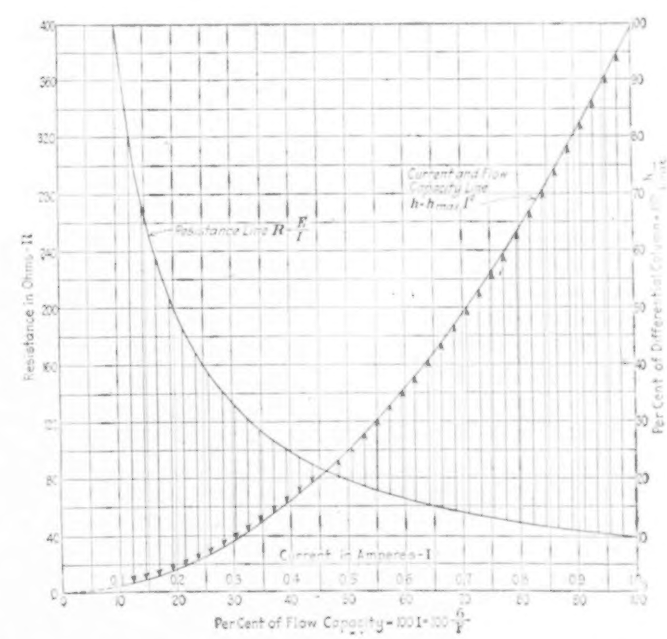


FIG. 3 DIAGRAM SHOWING RELATION BETWEEN UNITS OF FLUID FLOW AND ELECTRIC UNITS

PRACTICAL APPLICATION

After the relations between the various factors had been determined, the problem reduced itself to the construction of a resistance which would be regulated by the differential column of the flow according to the solution of Equation [12]. The first attempt in this direction was made by inserting a continuous

resistance coil in a water manometer where the height of the water column would reduce the amount of resistance in the coil by short-circuiting the part immersed in the water. The first trials were made with direct current, and while it was anticipated that electrolytic action would be set up between the metal conductors and the water, it was nevertheless expected that this action would not take place when alternating current was used.

There was little information available on the subject and it was therefore necessary to determine experimentally the amount of resistance needed. After obtaining some idea of the amount required and being hindered by the accumulation of deposit in the container, which was at first attributed to the electrolytic action of the direct current, provisions were made to continue the experiments with alternating current. It was discouraging, however, to note that practically the same action took place between the metal conductors and the water when alternating current was used. Repeated analyses of samples of the deposit disclosed that it was a formation of oxide, due to the corrosion of the metal conductors in contact with the water.

Besides the formation of deposits, there were other disadvantages in short-circuiting the metallic resistance by a water column. On one hand the conductivity of the water varied with its hardness, thus introducing a variable resistance in the part of

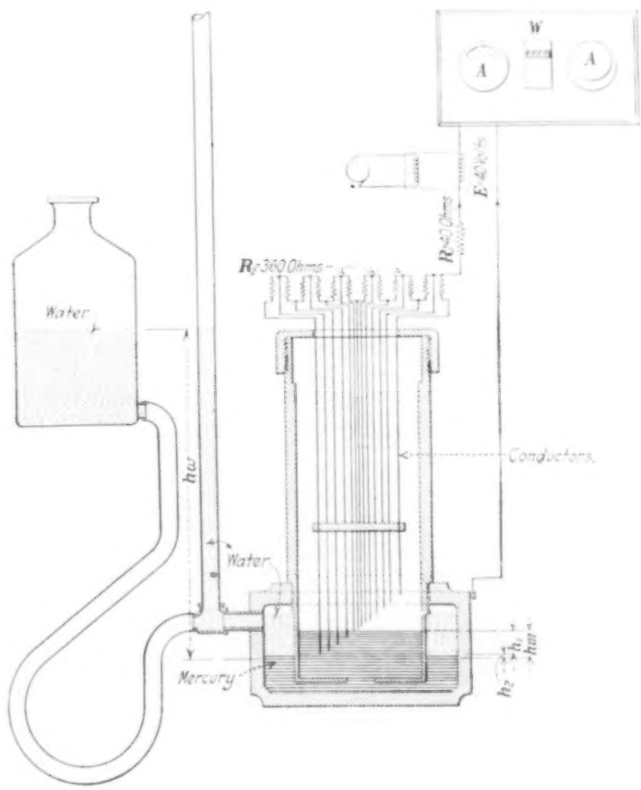


Fig. 4 Device in which Rise of Mercury Column Regulates Amount of Current

the column which was covered by water, and on the other the vapors formed over the surface of the water had a tendency to short-circuit the resistance coils, again introducing a similar variable in the portion of the column above the level of the water. When repeated attempts to eliminate these defects had failed it was decided to adapt mercury instead of water for the regulating column of the instrument. The use of mercury, however, necessitated radical changes in the form of the device. The effective column of mercury for the average velocity pressure would be too small to cover the continuous resistance coil and produce the desired regulation of the resistance. It was therefore found necessary to regulate the resistance by steps through conductors coming in contact with the top of the mercury column. Fig. 4 shows the elementary form of experimental device adapted for this purpose.

In this elementary device the successive conductors were divided into steps of equal height from the zero level of the mercury column. The electromotive force of the circuit was maintained constant at 40 volts. The resistance of the circuit, which amounted in all to 400 ohms, was subdivided by the contact rods into 40 consecutive steps, and the amount of resistance provided for each step was determined from Equation [12]. Using these values the maximum current of 1 ampere corresponded to the minimum resistance of 40 ohms, while the minimum current of 0.1 ampere corresponded to the maximum resistance of 400 ohms.

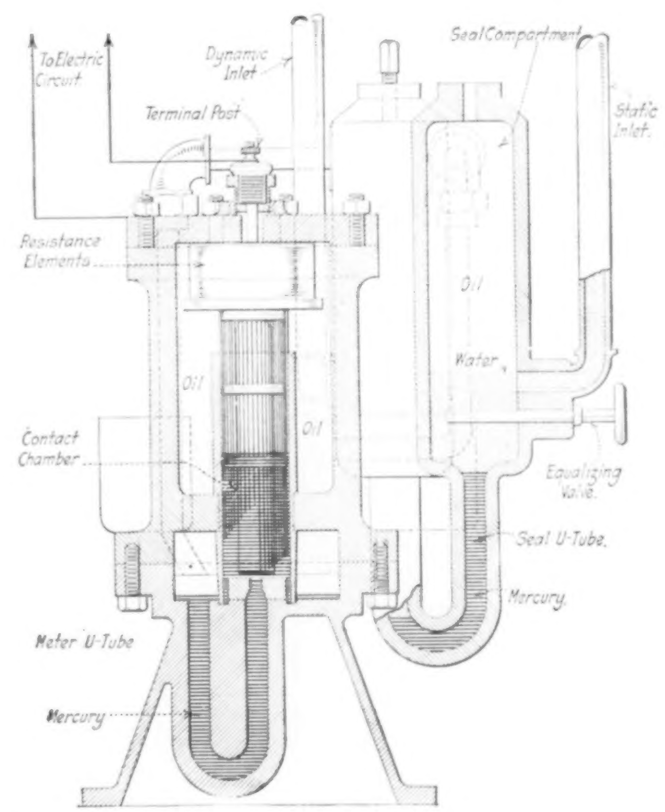


Fig. 5 Latest Type of Author's Flow Meter with Mercury Seal

Between these limits the rise and fall of the mercury column produced by the variation of the head on the high-pressure side of the U-tube would vary the amount of resistance in the circuit in accordance with the hyperbolic curve shown on the left of Fig. 3, thereby regulating the amount of current passing through the circuit in accordance with the parabolic curve on the right of the figure.

The operation of the elementary device was successful from the very start, but only as long as the contact chamber was kept free from water did the regulation of the current correspond with the variation of the head or the height of the mercury column. On the other hand, the instrument when equipped with an oil seal and connected to a pitot tube in the steam line could not be made to operate properly. When left under pressure the oil would leak through the fiber plug and allow water to get into the contact chamber, which would immediately put the instrument out of order.

To overcome this action the body of the instrument was extended to include also the resistance coils attached to the contact rods and the circuit completed through a plug connecting the internal and external resistances together. This change eliminated the leakage of oil from the instrument, but still the water could not be kept out of the chamber for any length of time. In some cases the water would blow through the mercury as soon as the pressure was admitted to the instrument. It was thought at that time that a bypass valve connecting the static and dynamic tubes when the pressure is admitted to the instrument would eliminate this trouble. After many changes in the original design an instrument

was made which for a short period of time was used as a steam-flow meter. In this instrument, besides the equalizing valve, an additional overflow chamber was provided to keep the water from reaching the conductors over the surface of the mercury. A terminal post replaced the connecting spark plug, thus allowing an adjustment of the position of the conductors with respect to the level of the mercury column. These additions, however, did not entirely eliminate the possibility of water coming in contact with the resistance elements of the device. With a uniform flow in the pipe the operation of the instrument would continue for some time, but when a slight disturbance of pressure occurred in the line it would cause the water to blow through the mercury into the contact chamber and this would immediately discontinue its operation.

Notwithstanding this objectionable feature, the convenience of the electric measurement of the flow and the fact that the instrument would function as long as there was no water in the contact

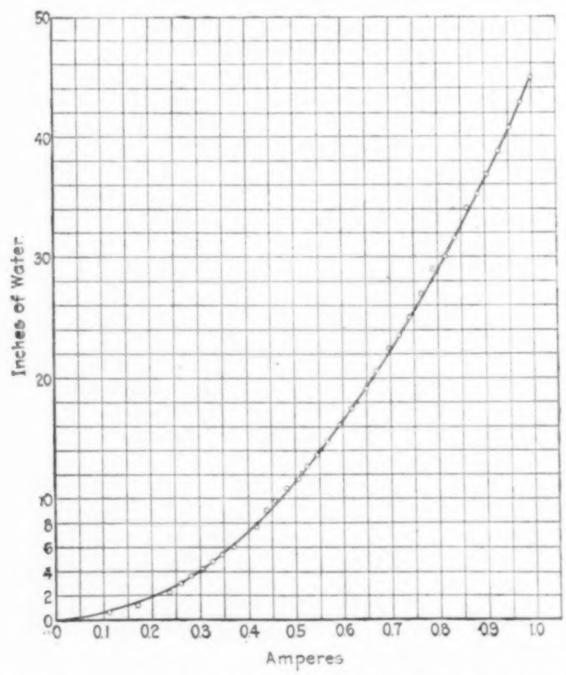


FIG. 6 COMPARISON OF CURVE OBTAINED FROM EQUATION [11] WITH DATA PLOTTED FROM TABLE 1

chamber, have encouraged further experimenting for the elimination of defects. The problem was finally solved in the fall of 1917 by the addition of a mercury seal connected in parallel with the working base of the instrument. The function of the mercury seal in this case is quite similar to that of a fuse plug in an electric circuit, with the added advantage that it is self-replacing. The principle of its operation is illustrated in Fig. 5, which shows a section of the meter body and seal chambers. It can be seen that the U-tube joining the two compartments of the seal will contain a column of mercury about one-half the height of the column in the meter body. Under normal operation the mercury column in the seal acts in unison with the mercury column in the meter body and does not interfere with the proper transmission of the differential pressure in the meter. When, however, some disturbance of pressure occurs in the line sufficient to break the seal, the mercury spreads over the larger area of the compartment, equalizes the pressure in the two compartments in the same manner as would an automatic opening of a bypass valve, and thus prevents the breaking of the higher column in the U-tube. As soon as the abnormal differential pressure is released, the mercury drops back into its place and reëstablishes the necessary seal between the two compartments. In this model a large quantity of oil is trapped in the two compartments of the seal and in the meter body, eliminating the possibility of water blowing through the mercury and coming in contact with the resistance elements of the meter.

In the latest type of the flow-measuring device the contact rods were changed from their former equal spacing above the zero level to spaces varying in height so as to give at each step equal increments of current representing equal amounts of flow. This was accomplished by gaging the length of the contact rods to follow the parabolic curve shown at the right in Fig. 3, which represents the solution of the equation $h = I^2 h_{max.}$ In the actual gaging of the contact rods $h_{max.}$ is taken as the distance between the zero level of the mercury and the end of the contact rod showing the maximum flow. The successive heights of the rods for the given equal increments of current are determined more conveniently by differentiating Equation [11], $h = I^2 h_{max.}$ The first differential, or $dh = h_{max.}\ (2IdI + dI^2)$, represents the respective increments of h corresponding to the given increments of I. The second differential, or $d^2h = 2h_{max.} dI^2$, represents the respective difference in the successive increments of h, from which it is noted that the distance between the successive contact rods is increased uniformly by the constant quantity $2h_{max.} dI^2$.

TESTING FOR ACCURACY

The accuracy of a flow-measuring device is necessarily made up of two factors. One is the accuracy with which the device registers the differential pressure equivalent to the flow in the pipe, and the other is the accuracy with which it will indicate or record this differential pressure or the equivalent units of flow. In the usual application of the flow meters, where the pitot tube, the venturi tube, or the orifice plate is used for obtaining the differential pressure of the flow, the efficiencies of these devices have been determined by numerous tests and are at present well known. Their nature is such that a given flow will always produce the same effect under the same conditions, since they do not possess any working parts to vary the relative effectiveness of their operation. On the other hand, the indicating or the recording elements of such devices may vary from time to time depending upon the condition of the moving parts in these elements. It is necessary, therefore, to have convenient means for testing them in order to ascertain their accuracy at frequent intervals.

Table 1 gives the data of a typical test on the resistance element of the flow-measuring device, showing the relation between the differential column and the corresponding readings of the electric current.

TABLE 1 DATA OBTAINED FROM TEST OF AUTHOR'S ELECTRIC FLOW-MEASURING DEVICE

($E_1 = 112$ volts)

h in. water	E_2 volts	I amperes	h in. water	E_2 volts	I amperes
0.45	40.15	0.110	16.12	39.45	0.592
1.06	40.15	0.170	17.43	39.45	0.618
2.06	40.15	0.235	19.44	39.35	0.642
2.81	40.05	0.260	21.00	39.25	0.666
3.56	40.05	0.280	22.75	39.25	0.689
4.00	39.95	0.305	24.00	39.25	0.713
4.56	39.95	0.326	25.25	39.25	0.740
5.125	39.85	0.347	27.00	39.25	0.765
5.875	39.85	0.370	29.125	39.15	0.790
7.00	39.75	0.392	30.00	39.05	0.814
7.56	39.65	0.418	31.625	39.05	0.838
9.125	39.75	0.434	34.06	39.05	0.860
9.875	39.75	0.458	35.37	39.05	0.882
10.812	39.65	0.480	37.00	39.00	0.905
11.25	39.55	0.505	38.75	38.90	0.930
12.50	39.65	0.523	40.75	38.80	0.953
13.56	39.55	0.542	42.875	38.70	0.978
14.87	39.55	0.566	44.75	38.45	1.000

In Fig. 6 the points obtained from the test are indicated by the small circles, and for comparison a curve is shown giving the theoretical relations according to the equation $h = I^2 h_{max.}$ In this test the differential pressure was obtained by varying the height of a water column connected to the dynamic side of the meter. The electric current was supplied to the indicating instrument through a transformer, and the primary or line voltage was kept

(*Concluded on page 487*)

The Design of Riveted Butt Joints

Simple General Equations for Use in Design, Derived from Schwedler's Graphical Method

By ALPHONSE A. ADLER,[1] BROOKLYN, N. Y.

In this paper Schwedler's graphical method of designing riveted joints is analytically treated by the author, who states the fundamental assumptions employed and submits brief evidence for their justification.

A general equation is derived to determine the pitch in any row, and another to determine the efficiency in ideal cases. The design of cover plates is also considered.

Actual joints are calculated, using commercial dimensions, and the close agreement found between the ideal and calculated efficiencies seems to indicate that the scheme of analysis is consistent. The design of a quadruple-riveted joint furnishes the data for the single-, double- and triple-riveted joints by simply omitting the extra rows of rivets.

In the design of riveted joints certain assumptions are made the justification of which is ascertained from their agreement with the results of experiments. Among the more important of these assumptions are the following:

a The tensile resistance of the joint is directly proportional to the net area under stress

b The shearing resistance of the joint is directly proportional to the total cross-sectional area of the driven size of rivets

c The bearing resistance of the joint is directly proportional to the total projected area of the driven size of rivets

d There is no bending stress in the rivets

e The frictional resistance of the joint is independent of the strength.

Of the foregoing, the first assumption is perhaps the one which involves the greatest discrepancy. This subject was studied by Coker[2] by means of an optical method. A perforated plate of xylonite was placed between the polarizer and analyzer of a pair of Nicol prisms. By this means Coker showed the intensity of stress around the rivet hole. An analytical treatment of this problem was given by Suyehiro[3] and his results show fair agreement with those obtained experimentally by Coker. Suyehiro further shows that if the hole in a plate is plugged, the resultant stress around the rivet hole is very much less. In the latter case it corresponds to a riveted joint when the rivets are driven, as only in this case can the plate be loaded. The stress intensity between the rivet holes, nevertheless, is not uniform.

Assumptions *b* and *c* are common in structural and machine design and are dealt with at length in the more important texts on strength of materials.

Assumption *d* is also common in structural design. Since the rivet completely fills the hole and the plates are comparatively rigid, there is little chance for bending and hence the bending stress is negligible.

The last assumption forms the basis of another method of designing joints the advantages of which are pointed out by Bach[4]. Briefly stated, joints in this country are designed for strength and checked for tightness, while in the method proposed by Bach the procedure is reversed and quite different from that in the former case.

After all, if actual joints are riveted up and tested to destruction, the data so obtained yield the maximum values of the stresses in tension, shear and bearing. If these values are then used in actual designs the process becomes reversible and errors made originally in the assumptions are automatically canceled. Indeed, this is the general plan followed in structural design today. For the limited sizes of plate and rivets used in boiler joints it should give results sufficiently reliable to inspire confidence. However, additional experimental data will always be useful.

Analytical Treatment

As is customary in riveted-joint design, the shearing resistance of a rivet is equated to the crushing resistance in order to find the smallest permissible diameter of rivet. Hence if d is the diameter of the rivet in inches, f_s' the shearing resistance in lb. per sq. in. per single surface in double shear, f_c' the crushing (or bearing) resistance in lb. per sq. in. in double-shear bearing, and t the thickness of the plates connected in inches,

$$\frac{\pi d^2}{2} f_s' = dtf_c' \qquad [1]$$

from which

$$d = \frac{2tf_c'}{\pi f_s'} \qquad [2]$$

In other words, if d is chosen in accordance with Eq. [2] the rivet is equally likely to fail in shear or crushing because of the condition imposed in equating the shearing and bearing resistances.

For reasons to follow, assume a strip of plate of width w inches to be bent around the rivet somewhat like the link of a chain but of rectangular cross-section. If the resistance of this link under tension is equal to either the shearing or the crushing resistance of the rivet and if R denote this resistance,

$$R = 2wtf_t$$

or

$$w = \frac{R}{2tf_t} \qquad [3]$$

where f_t is the tensile resistance of the plate in lb. per sq. in.

The idea of conceiving a plate to be divided into hypothetical tension strips the resistance of each of which is equal to the strength of a rivet, first occurred to Schwedler,[1] who used it as the basis of a graphical method. Unwin[2] has applied this method to boiler joints, but it is cumbersome and does not lend itself to slight changes in the assumed data without entailing a comparatively large amount of effort. An attempt to avoid this led to an analytical treatment which was published by the writer in 1916.[3] It was found later that the steps in this analysis could be concisely expressed by simple general equations, and these are the subject of this paper. A sufficient part of the article referred to is repeated here in order to insure continuity of treatment.

Fig. 1 shows a single-riveted joint in which the cover plate nearest the observer has been removed for convenience. The tension strips are shown around the rivet. The portion between the tension strips (shown shaded) could be cut out of the plate without impairing its strength. Of course in an actual boiler this could not be done, since this metal is required to enclose the contents.

Fig. 2 shows a commercial quadruple-riveted joint with the distance between the rivet rows greatly exaggerated and in which the rivets are not staggered. The tension strips are numbered for convenience. It will be found that, starting below with any strip, it may be traced around a rivet and back again, thus showing that each strip has a particular rivet the resistance of

For presentation at the Spring Meeting, Detroit, Mich., June 16 to 19, 1919, of The American Society of Mechanical Engineers. All papers are subject to revision.

[1] Assistant Professor of Mechanical Drawing and Design, Polytechnic Institute of Brooklyn. Mem.Am.Soc.M.E.

[2] *Engineering* (London), March 28, 1913, p. 439.

[3] *Engineering* (London), August 14, 1914, p. 231.

[4] Bach, Die Maschinen-Elemente, chapter on Nietverbindungen.

[1] Ueber Nietverbindungen. Lecture by J. W. Schwedler before the Architekten Verein zu Berlin; reprinted in their Wochenblatt, Nov. 22, 1867, et seq., pp. 451, 461 and 472.

[2] Machine Design, vol. 1.

[3] *Power*, August 1, 1916.

which it adds to the total resistance of the joint. The problem therefore rests on finding the maximum resultant strength.

If w is the width of a strip and d is the diameter of the rivet, then from Fig. 1 the most economical pitch for the first row of rivets occurs when the tension strips just touch each other. Denoting this pitch by p_1,

$$p_1 = 2w + d \quad\quad [4]$$

The shaded area is metal available for rivets in subsequent rows. Thus in each pitch there is available a strip of width d. If m_1 represents the available metal per inch, then

$$m_1 = \frac{d}{p_1}$$

But since the amount of metal required to insert extra rivets in

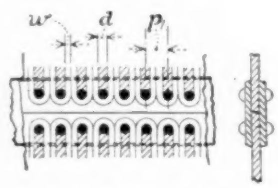


FIG. 1 SINGLE-RIVETED BUTT JOINT

a second row is a strip of width $(2w + d)$, the pitch of the second row is

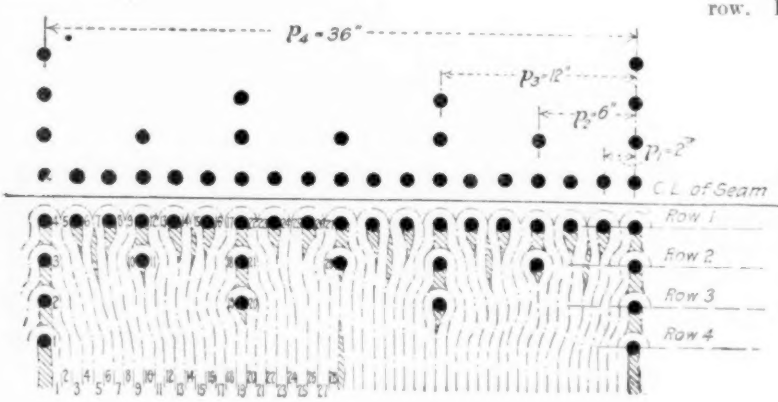


FIG. 2 LAYOUT OF A QUADRUPLE-RIVETED BUTT JOINT

$$p_2 = \frac{2w + d}{m_1}$$

Since, however, from Eq. [4] $p_1 = 2w + d$ and $m_1 = \frac{d}{p_1}$, the pitch p_2 may be written

$$p_2 = \frac{p_1}{d/p_1} = \frac{p_1^2}{d} \quad\quad [5]$$

Similarly, there is available for rivets in a third row a width of metal d in each distance p_2, or the width of available metal m_2 from the second row per inch of width of seam is

$$m_2 = \frac{d}{p_2}$$

Hence the pitch of the third row is

$$p_3 = \frac{2w + d}{m_2}$$

and replacing the values of numerator and denominator as before,

$$p_3 = \frac{p_1}{d/p_2}$$

But since p_2 is given in terms of p_1 by Eq. [5], this substitution results in

$$p_3 = p_1 \div \frac{d}{p_2}$$

$$= p_1 \div \frac{d}{p_1^2/d}$$

or

$$p_3 = \frac{p_1^3}{d^2} \quad\quad [6]$$

In the same manner

$$m_3 = \frac{d}{p_3}$$

$$p_4 = \frac{2w + d}{m_3}$$

$$= p_1 \div \frac{d}{p_3}$$

$$= p_1 \div \frac{d}{p_1^3/d^2}$$

or

$$p_4 = \frac{p_1^4}{d^3} \quad\quad [7]$$

Therefore it will be seen in Eqs. [4], [5], [6] and [7] that the subscript of p in the left-hand member is the same as the exponent of the numerator p_1 in the right-hand member and is one greater than the exponent of d in the denominator. For a general equation, let n signify the number of the row; then it follows that

$$p_n = \frac{p_1^n}{d^{n-1}} \quad\quad [8]$$

To try a simple check, the equation should hold for the first row. Let therefore

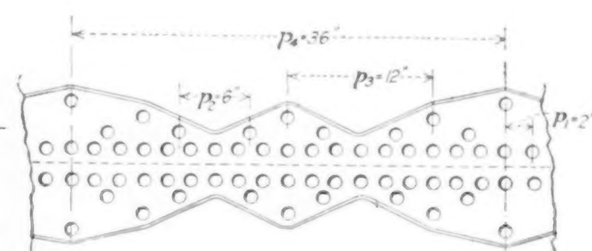


FIG. 3 SCALLOPED COVER PLATE FOR QUADRUPLE-RIVETED JOINT

$$p_1 = \frac{p_1^1}{d^0}$$

or

$$p_1 = p_1$$

which as it stands conveys little information; but recourse to Eq. [4] shows it to be equal to $2w + d$.

A general equation for the efficiency of a Schwedler joint is also possible. Thus, in an ideal joint all manners of failure are equally likely. Choosing the most convenient form for the equation, take the case for the efficiency in tension of the last row, namely:

$$e_n = \frac{(p_n - d)\,tf_t}{p_n t f_t}$$

$$= \frac{p_n - d}{p_n}$$

$$= 1 - \frac{d}{p_n} \quad\quad [9]$$

As p_n becomes very large by increasing the number of rows, the efficiency approaches unity or 100 per cent.

A slightly different form might be obtained for the general equation of the efficiency. Since p_n in Eq. [9] may be replaced by its value from Eq. [8],

$$e_n = 1 - \frac{d}{p_1^n/d^{n-1}}$$

$$= 1 - \frac{d^n}{p_1^n}$$

$$= 1 - \left(\frac{d}{p_1}\right)^n \quad\quad [10]$$

This equation expresses the same result as Eq. [9]. For example, the ratio d/p_1 is always less than unity, and the fraction raised to any positive power will approach zero as n becomes large. Again, the efficiency approaches 100 per cent as the number of rows is increased.

For high-efficiency joints the cover plates must be designed from fundamental principles rather than from the empirical rules given in certain textbooks. On the plate the tension strips must all pass through the last row of rivets. On the cover plates the condition is just the reverse, that is, the strips all pass through the first row of rivets. Since the pitch and tensile stress are fixed, the required area of metal may be obtained by suitably determining the thickness.

The total load on a strip of plate of width p_1 is

$$\frac{p_1 t f_t e}{100}$$

where e is the actual efficiency of the joint in per cent. The resistance of two cover plates is

$$2\ (p_1 - d)\ t_c f_t$$

where t_c is the thickness in inches of one cover plate. For equal strength these must be equated; hence

$$2\ (p_1 - d)\ t_c f_t = \frac{p_1 t f_t e}{100}$$

from which

$$t_c = \frac{p_1 t e}{200\ (p_1 - d)} \quad \ldots\ldots\ldots\ldots\ldots [11]$$

Application of the Method

Assume a plate ½ in. thick. Let f_t = 60,000 lb. per sq. in., f_s' = 45,000 lb. per sq. in., and f_c' = 100,000 lb. per sq. in. From Eq. [2],

$$d = \frac{2 \times \frac{1}{2} \times 100{,}000}{\pi \times 45{,}000} = 0.707 \text{ in.}$$

The value of R in Eq. [3] is obtained from the shearing or bearing resistance in Eq. [1]. Thus for shear,

$$R = \frac{\pi \times (0.707)^2 \times 45{,}000}{2} = 35{,}300 \text{ lb.}$$

From Eq. [3]

$$w = \frac{35{,}000}{2 \times \frac{1}{2} \times 60{,}000} = 0.588 \text{ in.}$$

Then from Eqs. [4], [5], [6] and [7]

$$p_1 = (2 \times 0.588) + 0.707 = 1.883 \text{ in.}$$

$$p_2 = \frac{(1.883)^2}{0.707} = 5.03 \text{ in.}$$

$$p_3 = \frac{(1.883)^3}{(0.707)^2} = 13.4 \text{ in.}$$

$$p_4 = \frac{(1.883)^4}{(0.707)^3} = 35.7 \text{ in.}$$

The corresponding efficiencies for these ideal joints are, from either Eqs. [9] or [10],

$$e_1 = 1 - \frac{0.707}{1.883} = 62.5 \text{ per cent (Single-riveted)}$$

$$e_2 = 1 - \frac{0.707}{5.03} = 85.9 \text{ per cent (Double-riveted)}$$

$$e_3 = 1 - \frac{0.707}{13.4} = 94.7 \text{ per cent (Triple-riveted)}$$

$$e_4 = 1 - \frac{0.707}{35.7} = 98.0 \text{ per cent (Quadruple-riveted)}$$

To design commercial joints from the foregoing, choose, say, d = 0.75 in., p_1 = 2 in., p_2 = 6 in., p_3 = 12 in., p_4 = 36 in., as shown in Fig. 2. This will afford a joint having simple ratios of rivet pitches from row to row. The calculated efficiencies for commercial riveted joints are found in the usual way. A simple calculation will show that R = 37,500 lb. in bearing. Hence no rivets will fail in shear since the shearing resistance is 39,000 lb. Thus, for a quadruple-riveted joint where the unit pitch is 36 in., it is necessary to consider—

a Bearing resistance of all rivets in a 36-in. strip
b Tensile resistance of row 4
c Tensile resistance of row 3 plus bearing resistance of row 4
d Tensile resistance of row 2 plus bearing resistance of rows 3 and 4
e Tensile resistance of row 1 plus bearing resistance of rows 2, 3 and 4.

The values of these resistances are as follows:

a	28 × 37,500	= 1,050,000 lb.
b	35.25 × 60,000 × ½	= 1,057,500 lb.
c	(33.75 × 60,000 × ½) + (1 × 37,500)	= 1,050,000 lb.
d	(31.50 × 60,000 × ½) + (4 × 37,500)	= 1,095,000 lb.
e	(22.5 × 60,000 × ½) + (10 × 37,500)	= 1,050,000 lb.

It will be seen that the liability of rupture will occur under items *a*, *c* or *e*. The resistance of an unperforated strip 36 in. wide is 36 × 60,000 × ½ = 1,080,000 lb. The efficiency is consequently

$$e = \frac{1{,}050{,}000}{1{,}080{,}000} \times 100 = 97.2 \text{ per cent}$$

The thickness of the cover plates is, from Eq. [11], approximately,

$$t_c = \frac{2 \times \frac{1}{2} \times 97.2}{200 \times 1.25} = \frac{25}{64} \text{ in.}$$

To make a triple-riveted joint, omit the rivets in row 4 of Fig. 2. A similar set of calculations will show that in a 12-in. strip failure is likely to occur through—

a Bearing resistance of all rivets in a 12-in. strip
b Tensile resistance of row 3
c Tensile resistance of row 2 plus bearing resistance of row 3
d Tensile resistance of row 1 plus bearing resistance of rows 2 and 3.

These resistances have respectively the following values:

a	9 × 37,500	= 337,500 lb.
b	11.25 × 60,000 × ½	= 337,500 lb.
c	(10.5 × 60,000 × ½) + (1 × 37,500)	= 352,500 lb.
d	(7.5 × 60,000 × ½) + (3 × 37,500)	= 337,500 lb.

The lowest resistance of the joint is for items *a*, *b* or *d*. The initial strength of the plate is 12 × 60,000 × ½ = 360,000 lb., hence the efficiency is

$$e = \frac{337{,}500}{360{,}000} \times 100 = 93.7 \text{ per cent}$$

The thickness of the cover plates is approximately

$$t_c = \frac{2 \times \frac{1}{2} \times 93.7}{200 \times 1.25} = \frac{3}{8} \text{ in.}$$

For a double-riveted joint omit rows 3 and 4 of the quadruple joint and the unit strip becomes 6 in. wide. In this case failure may occur through—

a Bearing resistance of all rivets in a 6-in. strip
b Tensile resistance of row 2
c Tensile resistance of row 1 plus bearing resistance of row 2.

Numerically these become

a	4 × 37,500	= 150,000 lb.
b	5.25 × 60,000 × ½	= 157,500 lb.
c	(3.75 × 60,000 × ½) + (1 × 37,500)	= 150,000 lb.

The strength of the original plate is 6 × 60,000 × ½ = 180,000 lb., hence the efficiency is

$$e = \frac{150{,}000}{180{,}000} \times 100 = 83.3 \text{ per cent}$$

The thickness of the cover plates is about

$$t_c = \frac{2 \times \frac{1}{2} \times 83.3}{200 \times 1.25} = \frac{11}{32} \text{ in.}$$

Finally, for a single-riveted joint omit rows 2, 3 and 4. The results for bearing and tension can be put down immediately as

a	1 × 37,500	= 37,500 lb.
b	1.25 × 60,000 × ½	= 37,500 lb.

The original strength of a strip 2 in. wide is $2 \times 60{,}000 \times \frac{1}{2} = 60{,}000$ lb., from which the efficiency is

$$e = \frac{37{,}500}{60{,}000} \times 100 = 62.5 \text{ per cent}$$

The thickness of the cover plates is

$$t_c = \frac{2 \times \frac{1}{2} \times 62.5}{200 \times 1.25} = \frac{1}{4} \text{ in.}$$

The efficiencies just calculated are compared in Table 1 with those obtained by using Eq. [9] or [10].

TABLE 1 IDEAL AND CALCULATED EFFICIENCIES OF DOUBLE-STRAPPED BUTT JOINTS

Type of double-strapped butt joint	Efficiencies, Per Cent	
	Ideal	Calculated
Single-riveted	62.5	62.5
Double-riveted	85.9	83.3
Triple-riveted	94.7	93.7
Quadruple-riveted	98.0	97.2

There are two things worthy of note in the method that has been presented. One is, that the design of a quadruple-riveted joint presupposes the design of the triple-, double- and single-riveted joints. Thus there is symmetry existing in all of these joints and manufacturers will find it easy to standardize them should it be found advisable to do so. The other follows from a discussion of the equations of bearing and tension on the plate. Equating these,

$$dtf_c' = (p_1 - d)\, tf_t$$

from which

$$p_1 f_t = df_c' + df_t$$

so that the expression for the pitch becomes

$$p_1 = d\left(1 + \frac{f_c'}{f_t}\right)$$

Since f_c' and f_t are properties of the materials used and therefore constants, the last equation might be written in the form

$$\frac{d}{p_1} = \text{constant}$$

This ratio appears in the equation for efficiency, Eq. [10], and due to the linear relation between p_1 and d the same efficiency might be obtained with an infinite number of values of d. For instance, if d is doubled then p_1 must be doubled, and so on. There is a certain minimum value that d might have in any joint and that value has been found in Eq. [2], where a smaller value will cause the rivet to fail by shear. Hence no ambiguity arises in this case. Commercial considerations require the smallest rivet in general, while for very thin plates where the rivet sizes are very small it is desirable to know that, even with these, good efficiencies may be obtained by increasing the pitch in the same ratio as the rivet diameter.

In connection with assumptions b and c at the beginning of the paper, the supposition is made that the shear and bearing are uniformly distributed among the rivets of a given joint. To prevent too serious a deviation from this premise, the cover plates might be designed in the following way: Let it be assumed at the start that each rivet is properly driven, then, in an ideal case, the same metal-to-metal contact exists among all the rivets. For this condition to prevail after loading requires that the same stress exist in the cover plate as exists in the connected plate. Under these conditions the deformation under load will be the same for both cover plates and connected plate. In commercial joints, departures from the ideal case arise which may be somewhat obviated by scalloping the cover plates for triple- and quadruple-riveted joints, as shown in Fig. 3. This will decrease the rigidity of the cover plate and to some extent prevent the rivets of the outer rows from taking an undue share of the whole load.

EXTINGUISHING AND PREVENTING OIL AND GAS FIRES

FOR the past three years the Bureau of Mines has been conducting investigations to determine the nature and the specific causes of oil and gas fires, with a view to suggesting means whereby they may be successfully combated, and even eliminated, if possible. In a bulletin recently issued by the Bureau, C. P. Bowie points out what has been done by operators in the past, and describes various fire-prevention methods and fire-fighting apparatus which are being used or adopted by many of the larger oil companies. These methods and apparatus, it is stated, if universally employed by operators, will largely decrease the present enormous annual losses, of which some idea may be found by quoting from the statistics of the Bureau that during the period of ten years from January 1, 1908, to January 1, 1918, approximately 12,850,000 bbl. of oil and 5,024,506,000 cu. ft. of gas were destroyed by fire in the United States.

Oil and gas fires are caused principally by lighting and frictional electricity, and to a lesser extent by carelessness. Static

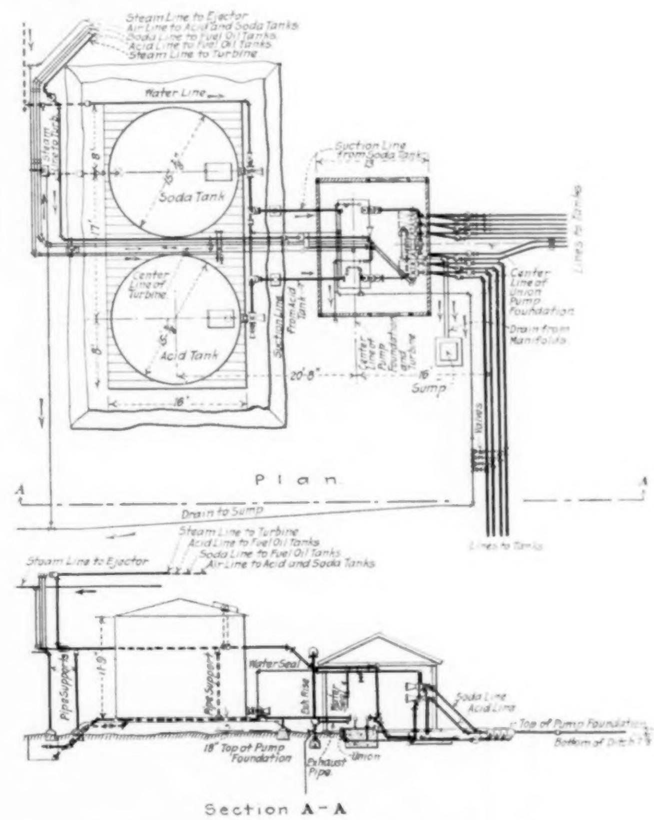


FIG. 1 GENERAL ARRANGEMENT OF SUCTION AND DISCHARGE PIPING AT PUMPS, FROTHY-MIXTURE SYSTEM

electricity accounts for the origin of a number of seemingly mysterious fires. An unpublished report of the chemist for the Massachusetts District Police to the chief of the Boston Fire Department mentions the following instances:

A chauffeur desiring to fill a large limousine, which was standing on the cement floor of a garage, took an ordinary 50-gal. can having a wooden handle on the bail, and hung it by this wooden handle on the hook of a self-measuring gasoline pump connected with an underground tank in the yard outside. He had drawn about a gallon when he heard a snapping noise, and the can was in flames. . . .

At another garage an employee filled a 5-gal. can with gasoline from a pump and took it to the running board of a car. He had an ordinary metal funnel across which was stretched a piece of chamois skin, and, to make the funnel sit upright on the car tank, he had attached a thin piece of wood, with a hole in it, for the funnel spout. He stood on the running board and held the pouring can quite near the edge of the funnel, but not touching it, when he saw a spark jump from the funnel to the can. It ignited the gasoline.

The explanation of the first fire is that the friction of the flow-

ing gasoline against the bottom and sides of the can generated electricity that charged the can: when the potential of the charge became too great, the discharge took place between the metal of the bail and the pump. The second case cited presented practically the same phenomenon. The funnel was insulated from the tank by the board at its base, and the funnel became charged with the electricity developed by friction of the gasoline flowing through the chamois skin.

Fires in oil tanks are successfully extinguished by the so-called frothy-mixture system. Essentially this system provides for bringing together two chemical solutions and for feeding into the top of burning oil tanks the thick, tenacious foam resulting from their combination, thereby excluding air and extinguishing the flame. The apparatus required in practice comprises two tanks—one for each chemical solution—a suitable pump, pipe lines to carry the solution to the oil tanks or reservoirs, mixing chambers where the chemicals can combine, and a means for properly distributing the foam.

The solutions for producing the foam may be any two compounds that on coming together form an abundance of relatively tough bubbles inflated with a non-inflammable gas. The chemicals must be fairly cheap; also they must not deposit any appreciable amount of sediment after having been in solution for a considerable time. The proportion of froth to solution should be about 6 or 8 to 1, that is, combining 50 cc. of each solution should produce 600 to 800 cc. of foam.

The installation put in by the Associated Pipe Line Co. at Coalinga, Cal., and shown in Fig. 1, was designed to protect four 55,000-bbl. oil tanks each 114 ft. 6 in. in diameter, one 30,000-bbl. tank 86 ft. in diameter, and two fuel-oil tanks each about 8 ft. in diameter. The solutions used at this station have the following composition:

Solution A	Parts by weight	Solution B	Parts by weight
Water	100	Water	100
Aluminum sulphate (crystal)	10	Ground glue	1¼
Sulphuric acid, 66 deg. B.	½	Glucose	½
		Sodium bicarbonate	7½
		Arsenious oxide	1-52

Other formulæ are:

Formula 1

Solution A	Parts by weight	Solution B	Parts by weight
Water	100	Water	100
Aluminum sulphate (crystal)	14	Sodium bicarbonate	9¼
Extract of licorice (powdered)	3		

Formula 2

Water	100	Water	100
Aluminum sulphate (crystal)	12	Sodium bicarbonate	10
Acetic acid	½	Ground glue	1
Ground glue	1	Glucose	¼
Glucose	¼		

The capacities of the solution tanks depend on the number of square feet of oil surface to be covered. On an estimate that 1 gal. of mixture (½ gal. of each solution) will produce 7 gal., or 1617 cu. in. of foam, to cover the oil in a 55,000-bbl. tank with 6 in. of foam would require about 2800 gal. of each solution. This quantity, of course, should be increased by using a reasonable safety factor.

Fires at gas wells, except at wells producing large volumes of gas, are, as a rule, not particularly difficult to overcome if the gas can be confined in one stream, because if the flow can be cut off for an instant the flame will be extinguished. When the gas flow has been confined in one stream the flame, unless it is very small, will always be some distance above the casing. The greater the pressure of the gas the longer this column of unburned gas will be. If enough steam or water can be directed against this part of the gas column to interrupt the stream of ascending gases momentarily, even the largest fire will be put out. In putting out gas-well fires with steam, the usual practice is to set up portable field boilers in the vicinity and surround the burning well with steam pipes terminated in goosenecks, which throw a fan-shaped spray of steam against the gas column. Steam is turned on from all boilers simultaneously; if the volume is sufficient, a blanket or cloud of steam will be formed and momentarily interrupt the gas stream just above the head of the casing, and the fire will be extinguished.

H. O. Ballard, of the Empire Gas & Fuel Co., has adapted the snuffer principle to a portable extinguisher. The device consists of a hood mounted on wheels and terminating in a valve to which is attached a piece of 14-in. pipe about 20 ft. long. The pipe can be extended to any desired length by screwing on more joints. On either side of the hood, midway of its height, is a short piece of 10-in. pipe also containing a valve. The hood is taken to the side of the burning well and upended over the fire, with the large valve opened and the two small valves closed. When the hood has reached its vertical position, the lower valves are opened and the large one closed, thereby cutting off the flame. If the flow of gas is so strong that the discharge from the 10-in. pipes may reach the top of the stack and ignite before the large valve can be closed, the 10-in. pipes are extended to a safe distance from the well before the valves are manipulated.

Oil-well fires are often much more difficult to overcome than gas-well fires, because the well may be producing in such large quantities that the oil is not all consumed in one tapering flame as with gas. Also, the burning oil soon heats the ground around the well so hot that, no matter how often the fire may be extinguished, it will immediately reignite. Consequently, no definite rules can be given for combating fire at oil wells, as each burning well presents a problem of its own. Special precautions should be taken against fires in oil wells, as the process of extinguishing them is always laborious and difficult. The practice of having a fire inside of the derrick has been the cause of many fires about drilling wells. Gas fires about oil wells being drilled are, in most instances, wholly inexcusable, as permitting gas to escape unchecked from the well is a wasteful and, as a rule, unnecessary procedure. All bearings about the machinery, especially the bull-wheel, calf-wheel and sheave-wheel bearings, should be kept thoroughly oiled. Static electricity generated by the band-wheel belt or other moving parts of the machinery has often caused fires; danger from this source can be prevented by grounding all machinery parts and providing belts with properly constructed copper brushes attached to a grounded pipe. Numerous other precautionary measures have been devised for cases where there is danger of the oil coming in contact with a flame or a spark.

The recent developments of wireless telegraphy have required the use of more powerful Hertzian waves than had been sent out by any station up to the time of the war. There are present, therefore, in the ether permeating and surrounding the atmosphere, numerous trains of waves traveling in all directions. It is altogether possible that one of these sets or a set resulting from a combination of several of them should come in contact with a number of conducting bodies so arranged in a casual manner as to form a Hertzian resonator of the required inductance, capacity and resistance to respond to the passing train. There would then be an ether wave excited in the system, a spark would be produced and a fire probably caused as the result of the passage of the wave.

Mr. George A. Le Roy has presented to the Académie des Sciences a note on the possibilities of a fire being produced in this manner. He conducted a laboratory investigation by means of an apparatus which he terms "inflammatory-resonator." It consists of a globular glass flask provided with four openings, two lateral, one at the top and one at the bottom. Through the lateral openings two electrodes are introduced and kept at the desired distance apart by an adjusting mechanism; they constitute the terminals of a Hertzian resonator. The bottom opening permits placing under the electrodes a plate which carries the inflammable substances; there is also at the bottom a connection for exhausting air with a pump, or introducing gases into the globe. Through the top are located the required measuring instruments.

Hertzian waves of relatively low intensity, generated by means of an ordinary Ruhmkorff coil, were sent through the instrument.

Mr. Le Roy asserts that iron electrodes facilitated the inflammation of cotton, amadou, paper, tow, etc. He, therefore, concludes that a condition may be produced in such a case as the piling of a number of cotton bales, when by the breaking of one of the iron bracings an open resonator is virtually formed.

THE HEAVY-OIL ENGINE

In line with the prevailing tendency of engineers of related branches to forgather and discuss their mutual problems, the New York Section of The American Society of Mechanical Engineers and the Metropolitan Section of the Society of Automotive Engineers held a well-attended joint meeting at the Automobile Club of America, on the evening of April 9, at which various topics connected with the development of the heavy-oil engine were dealt with in brief addresses. Dr. Charles E. Lucke, Dean of the School of Mechanical Engineering, Columbia University, and late Director of the U. S. Naval Gas Engine School, presided over the meeting.

J. H. Smootz, of the U. S. Bureau of Mines, Petroleum Division, spoke on the methods employed in refining petroleum, and in obtaining lighter oils from the heavier fractions by the cracking process, as well as on the general properties of the various products. From the 13-odd billion gallons of petroleum annually produced in the United States, 1.8 billion gallons of kerosene were obtained and twice as much gasoline; the remainder being gas oil, distillate and light and heavy residuals, which latter were convertible into distillate. Costs of treatment were low and selling prices of the various products were purely dependent on the demand. Kerosene was relatively scarce and in his opinion not a fuel that would affect the situation to any considerable degree.

Dr. Lucke, in discussing the adaptation of the engine to the fuel, called attention to the necessity of heated vaporizing appliances when heavy gas oils and kerosene were used as engine fuels, and to the advantages of late injection. The heaviest, unvaporizible oils if injected in a fine enough spray, well scattered and homogeneously mixed with air, would explode as if gaseous. There was no question but that the engineers could adapt the engine to the fuel, and the chemists would see to it that cheap fuels were supplied. The important problem ahead was to adapt the engine to its various uses, and the interchange of ideas at meetings like the one in session would contribute largely to bringing this about.

J. M. Hunt, of the Dayton Engineering Laboratories Company, told of the possibilities of adapting automobile engines to fuels heavier than motor gasoline, and of experimental work he had carried on in this direction, particularly with kerosene. One car had been run 14 months on this fuel, covering 12,000 miles and without engine trouble developing. Preheated air was used and the mixture heated to 220 deg. and then compressed. Another way to avoid the difficulties of starting with a cold engine was to use two fuels, one highly volatile, to warm up the engine, but this involved needle-valve troubles. In regard to the kerosene "knock," experiments at Dayton had shown this to be due, not to preignition, as many supposed, but to abnormal pressures—three to five times the normal explosion pressure—developed probably through the detonation of some product of combustion. The introduction of water or cool exhaust gas had been suggested as remedies for knocking, but manifestly this was not a final solution. The problem ahead was to design engines to use fuel and gas oils, for the limits of the gasoline and kerosene supply were already in sight.

A short paper by A. H. Goldingham, of the De La Vergne Machine Co., on the heated-metal type of heavy-oil engine, was read in the author's absence by the chairman. The desiderata in an engine of this type, it was stated, were reliability, first cost and economy. As to reliability, engines would run six months continuously, using any fuel, and with an odorless and practically invisible exhaust. This had been accomplished by thorough atomization and aeration of the oil sprayed in under 4000 to 5000 lb. pressure; improved construction of vaporizing chamber; and by the use of forced-feed lubrication, an automatic air starting valve and an improved vaporizer heating lamp or electric heating coil. Four-cycle engines up to 400 hp. running at 900 ft. per min. piston speed cost today $120 per hp. as against $55 in 1913, and weighed 425 lb. per b.hp. They operated regularly on 0.4 lb. fuel per b.hp., and at 6 cents per gal., $1000 would buy the fuel for a 100-hp. engine for a year.

Mr. Hansen, of the Skandia Pacific Oil Engine Co., told of his experience on the Pacific Coast in connection with the installation of Werkspoor engines in the wooden ships built by the Emergency Fleet Corporation. These ships had been constructed of green timber, with the result that there were many bedplate breakages due to shrinkage and warping of foundations, but charged nevertheless against the engines. Large hot-bulb engines required care, but it had been impossible to train properly the large number of engineers needed in the time available.

T. O. Lisle, editor of *Motorship*, said that the new type of motorship developed by the United States during the war—the wooden auxiliary—had been unsuccessful, as in addition to being constructed of green timber, they had been equipped with insufficient sail power so that the auxiliary engines were forced to the limit, and it had furthermore been necessary to operate them by untrained engineers. A 5000-ton boat had been provided with an engine of only 700 hp. In his opinion steel hulls should be adopted for such vessels and the powering raised, to range from 500 hp. for a 2000-ton boat up to 1100 hp. for a 5000-ton vessel. Stationary Diesel engines had been so developed that six-cylinder 4000-hp. engines were now being built and 5000 hp. was possible. A 20,000-ton 16-knot boat equipped with large power units would require space for but 14 tons of oil per 24 hours, and but 20 men in the engine room. He believed it would have been much better if the Emergency Fleet had consisted entirely of motorships. Eighty-six concerns were now building Diesel engines—50 on a large scale, and 150 concerns semi-Diesels. As to reliability in service, he would cite the *Zeelandia*, a vessel of 7500 tons built in 1912 and with engines of 2750 i.hp., which had sailed a total of 327,000 nautical miles at an average speed of 10.4 knots and had consumed 11,667 tons of fuel oil in her 31,600 hours at sea.

In the brief discussion which followed, referring to the matter of reliability, J. H. Norris stated he had been told that a motorship had never had to be towed into port.

H. C. Verhey, of the engineering staff of the Emergency Fleet Corporation, who had had twelve years' experience with Diesel engines and was familiar with European conditions, said that the materials of construction available in the United States were of superior quality and it was not necessary now to go abroad for designs, engineering talent or workmanship. Moreover, facilities here were better and our castings could not be surpassed in excellence by anything in Europe.

Harte Cooke, of the McIntosh & Seymour Corp., in discussing Diesels for stationary use, said that with the lighter fuels, if the fuel valve was too hot, the oil would crack and clog the burner plates. Careful cooling of the fuel valve would do away with this, but it was better to use a heavier grade of fuel. All oil fuels available could be successfully burned, even those carrying sulphur. With the latter, however, it was best to run a short time with sulphur-free oil before shutting down. This would carry the SO_2 out of the system and prevent the piping from being attacked.

Preceding the meeting, dinner was served in the grill room of the Automobile Club. The arrangements were in the hands of W. W. Macon, Chairman of the A.S.M.E. New York Section, and A. M. Wolf, Secretary of the S.A.E. Metropolitan Section. Before the speakers of the evening were introduced, Mr. Macon stated that the gathering was but one of a series of special meetings planned to secure closer coöperation among the various local organizations of engineers.

Raw Material, heretofore issued as *The Metal Record and Electroplater*, made its initial appearance under the new name with the March 1919 issue. This journal has recently been acquired by the Gage Publishing Company, well known as the publishers of the *Electrical Record* and *Electrical Export*, and it is planned to considerably widen the field of *Raw Material*. The new editor in chief is R. L. Herrick, formerly western editor of *Mines and Minerals*, later of the staff of the *Engineering and Mining Journal*, and until recently assistant publicity manager of the Ingersoll-Rand Company, of New York.

Electric Welding as Applied to Ship Construction

By H. JASPER COX,[1] NEW YORK, N. Y.

FEW subjects offer as great inducements for experimental research as that of the application of electric welding to shipbuilding, and it is doubtful whether in the whole range of applied science intimately concerned with practical developments in both industries greater potentiality is open than under the various headings in which the subject of electric welding naturally divides itself.

Although electric welding, and especially arc welding, has been used for a long time to great economical advantage in ship-repair work and marine engineering, it has been but little understood, and it is not overstating the case to say that it is only within recent months that any serious attempt has been made to analyze the elements of the art and determine the underlying scientific principles involved.

The chief investigator in this field was the General Engineering Committee of the Council of National Defense, which has made a very careful study of the application of spot welding to ship construction. In January 1919, however, this committee was dissolved and the Electric Welding Committee of the United States Shipping Board, Emergency Fleet Corporation, was appointed to investigate the whole field of electric welding and to advise the Emergency Fleet Corporation as to how the shipbuilding program might be speeded up and work economized by a wider adoption of the process.

The committee is composed of shipbuilders, electrical engineers, many prominent physicists and metallurgists, and of representatives of the Emergency Fleet Corporation, Classification Societies and Bureau of Standards, with Prof. Comfort A. Adams, of the Massachusetts Institute of Technology and President of the American Institute of Electrical Engineers, as Chairman.[2]

Much useful work has already been accomplished by the committee, data collected, investigations and research work carried out and important facts established. In the meantime similar investigations and research work were being conducted abroad, particularly in Great Britain, where an exhaustive series of practical experiments has recently been completed by the Technical Committee of Lloyd's Register of Shipping.

The results of these investigations have been not only encouraging, but have led to the conclusion that under certain prescribed conditions an electrically welded joint may with reasonable safety be applied to the main structure of a vessel.

Methods of Welding

The methods of electric welding applicable to ship construction can be considered under two main headings, resistance welding and arc welding.

Resistance Welding. As the term implies, it is the resistance offered to the flow of electric current through the material and contact surfaces to be united which causes the metal in the path of the current to heat up to the necessary temperature. Welding is then accomplished by the application of pressure. There are two distinct kinds of resistance welding—spot welding and butt welding.

Spot welding has been extensively used for jointures of thin metal such as ventilators, lifeboats and railway cars, and with considerable success, but it is only recently that its application to sheet plates and bars of the thickness required in ship construction has been investigated.

The two or more pieces to be welded are overlapped or superposed to form the joint and clamped between two copper electrodes; then current is passed through and pressure applied. In order to insure a successful weld the pressure should be sufficient to cause the metal to "flow" at the weld and to extrude all oxides, slag, etc., which may form. The pressure is maintained for a short time after the current is cut off, and the operation is then repeated at the next spot. Small buttons or disks of metal are sometimes placed under one or both of the electrodes, and when of proper thickness are completely submerged in the plate metal during the operation of forming the weld.

Intensive research work is now being conducted along these lines by the General Electric Company, who have built a heavy spot-welding machine, shown in Fig. 1, with a capacity of 100,000 amperes at 20 volts and a hydraulic pressure of 36 tons at the electrodes. A careful series of experiments is being carried out with this machine, using plates of from 1/4 in. to 3 in. in total thickness, and it has already been demonstrated that satisfactory spot welds can be made within this range. It has also been found that an appreciable range is permissible in the variables of current, pressure and time without seriously impairing the efficiency of the weld for a given thickness of material.

Where considerable tensile pull is anticipated in an overlap joint, it is considered desirable to have a double row of spots to prevent the tendency to bend and tear out the spots in the same manner as the countersunk heads of rivets are sometimes torn through the holes in a single-riveted overlap.

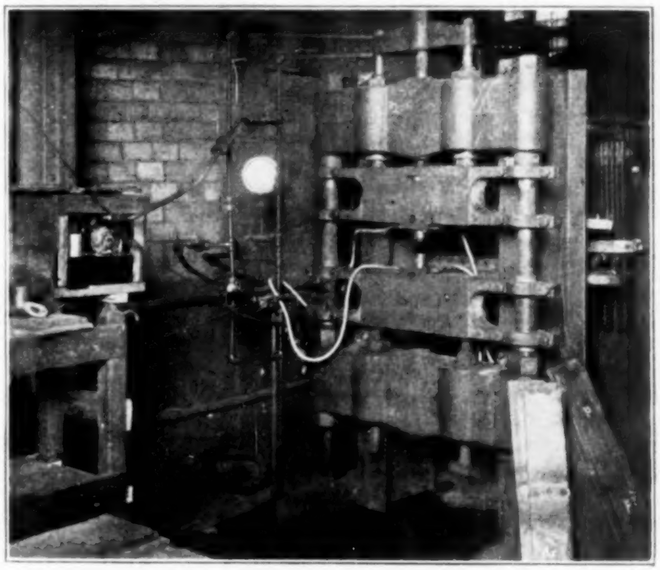


Fig. 1 Spot-Welding Machine made by General Electric Co. Current Capacity, 100,000 amperes; Pressure, 36 tons

Figs. 2 and 3 show some joints made during these experiments, which at the time of writing are still proceeding, and will no doubt shortly yield definite and comprehensive data. Although this method of welding has not yet reached the stage of development which might warrant its practical application to ship construction, it offers every prospect of doing so within the very near future. Obvious developments with this system are multiple spot and continuous or seam welding, both of which will tend toward great saving in time. In general, spot welding is much more rapid than arc welding and requires less labor, but more power and a much heavier and more expensive machine.

Butt welding is especially applicable to bars of uniform section and will probably have a broad future in jointing the reinforcements in ferro-concrete construction. The bars to be welded are brought together, end on, clamped and a low-pressure current passed through until a welding heat is obtained. Then end pressure is applied until the metal at the joint shows signs of squeezing

Abstract of paper presented at the Annual Meeting of the Society of Naval Architects and Marine Engineers, Philadelphia, on November 14 and 15, 1918.

[1] Lloyd's Register of Shipping.

[2] Representatives of the gas-welding industry have recently been added to this committee, and the title changed to The Welding Committee.

out. A machine for this type of welding has been ordered by the Emergency Fleet Corporation and will be tried out during the construction of a 3500-ton (dead weight) reinforced-concrete steamer now being built by the Fougner Concrete Shipbuilding Company.

Arc Welding. In this method of welding the electrode and the material to be welded are connected in a simple electric circuit and an arc is struck by bringing the electrode in contact with the work at the point where the weld is to be made, then withdrawing it slightly to obtain the desired length of arc. The two principal methods of applying this process are by means of the carbon arc and the metallic arc.

In the former a carbon electrode is used and the heat from the arc produced brings the metal to a fusion heat. When welding with the carbon arc additional metal is introduced into the arc and fused into and with the parent metal at the joint. Its main field of application, however, is in rough cutting in foundries and steel mills and for the repair or building-up of imperfect castings. It has not been advocated for use in ship construction generally and there are a number of reasons which make it doubtful whether it ever will be.

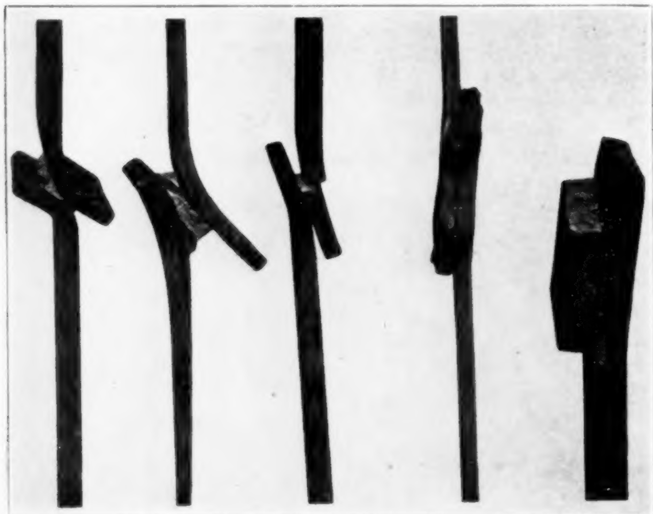


Fig. 2 Electrically Welded Steel Plates After Being Tested in Tension

In metallic-arc welding a metal electrode is used of approximately similar material to that being welded, the electrode itself is fused by the arc, and molten particles are carried over the arc into the fused portion of the parent metal, thus gradually building up the joint.

The actual operation, however, is not quite so simple as this sounds, as there are a large number of variables, any one or any combination of which may affect the efficiency of the result to a greater or less extent. These variables may be enumerated as follows:

1 The type of electrode, i.e., bare metal or covered
2 Chemical composition of the electrode
3 Chemical composition of metal being welded
4 Size of electrode
5 Kind of current, i.e., alternating or direct
6 Amperage and voltage
7 Skill of the operator
8 Method of preparing and building up the joint.

Training of Welders

Of these the skill of the operator is still the most vital factor, and it is probably because of this that arc welding is known as an art rather than a science. A skilled and properly trained welder knows instantly whether or not he is making a good weld. He can tell this by the smoothness of the flow of metal, the uniformity of the sound and light of the arc, and by the lack of "spattering" or deposition of "beads." When his arc is not welding he should immediately cease work, remedy the cause, whether it be unsuitable current control or faulty electrode, and, before proceeding again, should chip out the bad work and especially where the arc was broken. It will be seen, therefore, that the welder should possess some knowledge of the elements of electricity, how it is generated, conducted and controlled, the melting point of the metals employed, and the properties of the particular electrode in use. In ship work he should understand the correct methods of preparing the various joints and their relative importance, together with the best methods of building them up. It is therefore a *sine qua non* of welding the main structure of a vessel that only skilled operators be used. Recognizing this, the Emergency Fleet Corporation has established a separate training and education department for electric welding and has opened schools for the training of operators and instructors in New York, Newport News, and the Great Lakes district.

Lloyd's Experiments on Electrically Welded Joints

When the development of electric arc welding had reached a stage at which its application to the main structure of a vessel, with all the attendant possibilities, appeared a feasible proposition, the Technical Committee of Lloyd's Register of Shipping, in accord with its traditions, immediately embarked upon an exhaustive investigation in order to determine at first hand the suitability of electrically welded joints for such work. A series of experimental tests was accordingly devised and carried out under the direction of the society's technical staff in England, extending over a period of many months.

It is commonly accepted that the tests imposed on manufactured material do not in any way represent the strains which may be experienced in practice. Such tests are rather based on simple means for determining the average reliability of the material. Thus, also, in this case no one particular test is likely to determine whether the welding process under trial is sufficient for the work it is likely to have to do. It is therefore necessary to approach the problem rather on the basis of circumstantial evidence and to decide from a number of different types of experiments whether, on the whole, the performance is satisfactory.

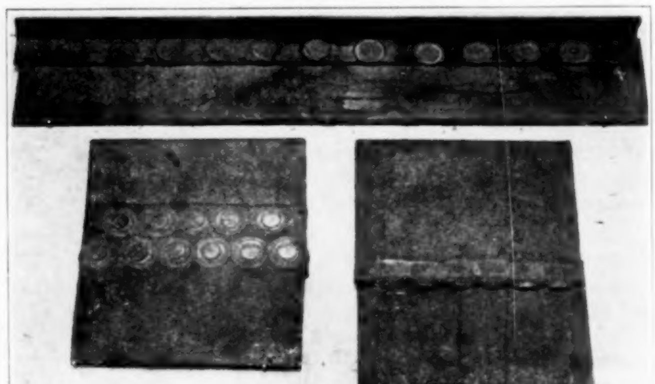


Fig. 3 Samples of Electric Spot Welding

The investigations were undertaken to determine the possibilities of the application of electric arc welding to shipbuilding, and, as it was desired to obtain as good a knowledge as possible of the physical properties of the combination of rolled and welded material, only highly skilled operators were employed. It must therefore be realized that the results of the experiments which have been made represent skilled practice, and that in general such performance can only be equaled with good workmanship and efficient supervision. The "Quasi Arc" process of electric arc welding was used throughout the experiments.

Nature and Description of Experiments

The general scope of the experiments included:

1 Determination of modulus of elasticity and approximate elastic limit
2 Determination of ultimate strength and ultimate elongation
3 Application of alternating stresses with (*a*) rotating specimens, (*b*) stationary test pieces
4 Minor tests, such as (*a*) cold bending of welds, (*b*) impact tests of welded specimens
5 Chemical and microscopic analysis
6 Strength of welds.

Tests were carried out on specimens as large as possible, particularly in respect to the static determinations of elasticity, ultimate strength and elongation, some of the test specimens being designed for a total load of just under 300 tons. The advantage of these large specimens was that the effect of workmanship was better averaged and the results were more comparable to the actual work likely to be met with in ship construction.

Fig. 4 illustrates the method adopted to measure the modulus of elasticity by means of a strainmeter designed by Dr. James Montgomerie, principal surveyor for Lloyd's Register in Scotland. The illustration shows the holders which were specially designed with a view to securing, as far as practicable, an even pull across the breadth of the plate. Readings were taken in way of the weld and at various points on the plate itself, both adjacent to and well clear of the weld, and the points at which these observations were taken are clearly shown in Fig. 5.

Typical results, illustrating the extensions as measured along the line *C*, are shown in Fig. 6, from which it would appear that the extensions in way of the weld do not show any marked difference from those at various points in the plain plate, the lines showing extensions in way of the weld lying among the others without disclosing any distinctive features. Measurements were also taken with the strainmeter set at right angles to the line of pull, the readings in this case, of course, representing contractions.

With a view to confirming this result a set of specimens of smaller size was prepared and tested. The curves obtained exhibit the same general characteristics as those of the large specimen and would appear to justify the inference that there is very little difference between the modulus of elasticity of the welded samples and that of the plain plate.

With alternating stresses the specimens were relatively of small size. For the rotating test pieces, circular rods, machined from a welded plate, were used, the diameters selected being 1 in. and ¾ in. These bars, about 3 ft. in length, were attached to a lathe headstock, and a pure bending moment in one plane was applied by means of two ball races to which known weights were attached. The material of the bar was thus exposed alternately to maximum tension and to equal maximum compression once in each revolution. The machine was run at about 1060 r.p.m.

Bars of identical material were tried in pairs, one specimen welded and the other unwelded, and the number of revolutions before the specimens parted was observed for various ranges of stresses varying from ± 15 tons to ± 6 tons per sq. in. Fig. 7 clearly shows the stresses at which the welded and unwelded bars will withstand a very large number of repetitions of stress.

In the second series of alternating-stress experiments flat plates were used of three thicknesses, viz., ¼ in., ⅜ in. and ½ in. These specimens were tried in groups of four, each group consisting of one plain, one butt-welded, one lap-welded and one lap-riveted plate. The specimens, which were about 14 in. long and 5 in. broad, were clamped along the short edges, so that the distance between the fixed lines was 12 in. Each plate was also clamped, near the middle, to the end of a pillar, which by means of a crank arm was caused to oscillate and to bend the specimen equally up and down by adjustable amounts (the maximum total movement in any of the experiments tried was 5/16 in). The machine was run at various revolutions (not exceeding 9 per min.), and the number of repetitions at which the specimen parted was observed. Typical results obtained are illustrated in Fig. 8, in which the ordinates represent total displacement from normal position, i. e., 2/16 in. means 1/16 in. up and 1/16 in. down.

The experiments on bending consisted of doubling the welded plate over a circular bar of diameter equal to three times the plate thickness and comparing the results with those of the plate of the same material, but unwelded. Fig. 9 shows the results obtained from the bending tests, and it will be noticed that the angle at which fracture occurs decreases rapidly with increased thickness of plate.

In the impact tests heavy weights were dropped from various heights on to the welded portion of a plate 5 ft. long and 2 ft. 6 in. in breadth, the weld being across the plate, parallel to the shorter edge. The deflections were noted and the condition of the weld was examined after each blow.

Other tests to determine the relative value of welding and calking under tension and the relative bearing value of a riveted or welded lug attachment are shown in Figs. 10 and 11. In the former, two plates are attached at right angles by an angle lug with closely spaced rivets and the angle calked on both edges, similar to the boundary angles of a watertight or oiltight bulkhead. The object of the test was primarily to ascertain at what stress the "tightness" of the attachment was destroyed as compared with that of the welded attachment. The results indicated

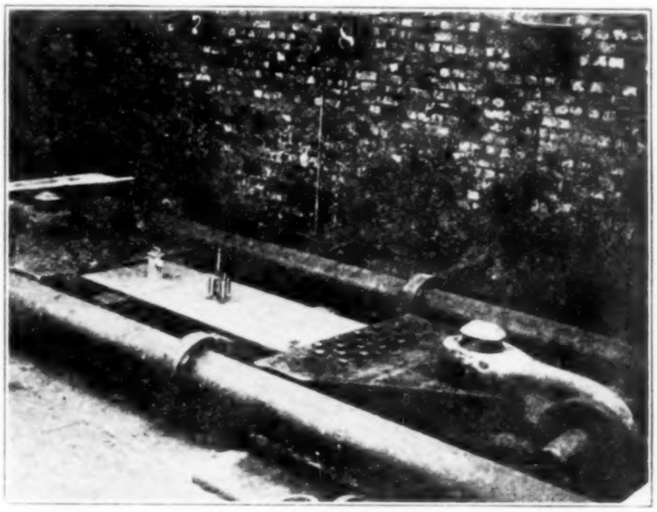


FIG. 4 LLOYD'S METHOD OF MEASURING MODULUS OF ELASTICITY

are very striking. The test shown in Fig. 11, in which a direct shearing force was applied to the lug attachment, indicates the relative values as between riveting and welding a lug attachment for such work as bracket connections. It will be observed that the welded lug is notched out at its mid-length and the welding applied only at the ends and in way of the notch.

The chemical and micrographical examination followed the ordinary practice.

Summary of Experimental Results

1 *Modulus of Elasticity and Approximate Elastic Limit*

a In a welded plate the extensions in the region of the weld are sensibly the same as for more distant portions of the unwelded plate.

b With small welded specimens containing an appreciable proportion of welded material in the cross-sectional area, the relation between extension and stress is practically the same, up to the elastic limit, as for similar unwelded material.

c The elastic limit (or the limiting stress beyond which extension is not approximately directly proportional to stress) appears to be slightly higher in welded than in unwelded material.

d The modulus of elasticity of a small test piece, entirely composed of material of the weld, was about 11,700 tons per sq. in. as compared with about 13,500 tons for mild steel and about 12,500 tons for wrought iron.

2 *Ultimate Strength and Ultimate Elongation*

a The ultimate strength of welded material with small specimens was over 100 per cent of the strength of the unwelded steel

plate for thicknesses of ½ in., and averaged 90 per cent for plates of ¾ in. and 1 in. in thickness.

b Up to the point of fracture the extensions of the welded specimens are not sensibly different from those of similar unwelded material.

c At stresses greater than the elastic limit, the welded material is less ductile than mild steel, and the ultimate elongation of a welded specimen when measured on a length of 8 in. only averages about 10 per cent as compared with 25 to 30 per cent for mild steel.

3 *Alternating Stresses*

a Rotating Specimens (round bar). Unwelded turned bars will withstand a very large number of repetitions of stress (exceeding, say 5 millions) when the range of stress is not greater than from 10½ tons per sq. in. tension to 10½ tons per sq. in. compression. Welded bars similarly tested will fail at about the same number of repetitions when the range of stress exceeds 6½ tons per sq. in.

b Stationary Test Pieces (flat plate). Butt-welded specimens will withstand about 70 per cent of the number of repetitions

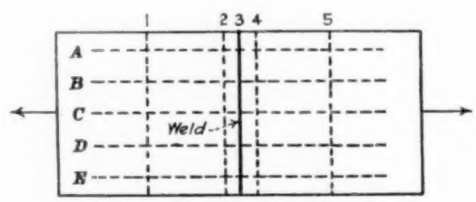


FIG. 5 POSITION OF READINGS, LLOYD'S METHOD

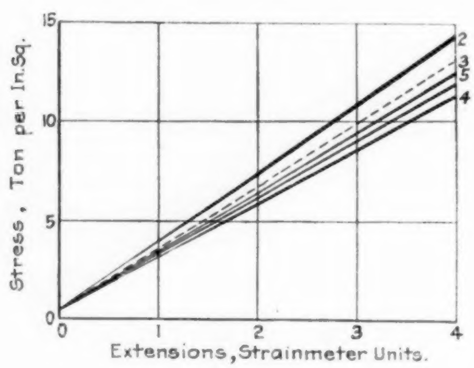


FIG. 6 EXTENSIONS IN DIRECTION OF PULL, READING ALONG LINE C OF FIG. 5

which can be borne by an unwelded plate. Lap-welded plates can endure over 60 per cent of the number of repetitions necessary to fracture a lap riveted specimen.

4 *Minor Tests*

a Welded specimens are not capable of being bent (without fracture) over the prescribed radius to more than about 80 deg. with ¼-in. plate, reducing to some 20 deg. where the thickness is 1 in. Unwelded material under the same conditions can be bent through 180 deg.

b Welded plates can withstand impact with a considerable degree of success; a ½-in. plate of dimensions already quoted sustained two successive blows of 4 cwt. dropped through 12 ft., giving a deflection of 12 in. on a length of about 4 ft. 6 in. without any signs of fracture in the weld.

5 *Chemical and Microscopic Analysis*

a Chemical Analysis. The electrode was practically identical with mild steel, but there was a greater percentage of silicon. The material of the weld after deposition was ascertained to be practically pure iron, the various other contents being carbon, 0.03; silicon, 0.02; phosphorus, 0.02; and manganese, 0.04 per cent, respectively.

b Microscopic Examination. The material of the weld is practically pure iron. The local effect of heat does not appear to largely affect the surrounding material, the structure not being much disturbed at about 1/16 in. from the edge of the weld. The amount of disturbance is still less in thin plates. The weld bears little evidence, if any, of the occurrence of oxidation. With welds made as for these experiments, i. e., with flat horizontal welding, a sound junction is obtained between the plate and the welding material.

6 *Strength of Welds*

a Butt welds have a tensile strength varying from 90 to 95 per cent of the tensile strength of the unwelded plate.

b Lap welds with full fillets on both edges have an ultimate strength in tension varying from 70 to 80 per cent of that of the unwelded material. With a full fillet on one edge and a single run of weld on the other edge the results are very little inferior to those where a full fillet is provided for both edges.

TABLE 1 COMPARATIVE STRENGTH OF RIVETS AND WELDED JOINTS

Thickness, in.	Diameter of rivet, in.	Breaking stress unperforated plate, lb. per sq. in.	Strength of plain plate, lb. per sq. in.	Percentage strength o joint
TRIPLE-RIVETED LAP JOINTS				
0.49	⅞	42,400	61,400	69.0
0.53	¾	38,300	54,700	62.5
LAP WELD—FULL FILLET—BOTH EDGES				
0.514	10.02[1]	45,300	63,600	71.0
0.730	8.76[1]	40,330	59,600	68.0
BUTT WELD—NOT STRAPPED				
0.505	10.66[1]	61,000	63,600	96.0
0.760	9.88[1]	54,680	59,600	91.5

[1]Total sectional area, square inches.

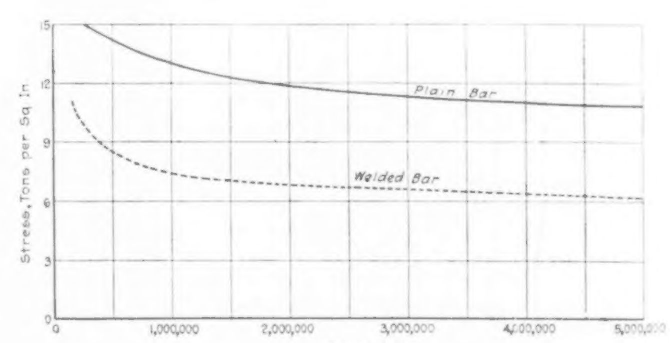


FIG. 7 ALTERNATING-STRESS TESTS ON ROTATING BARS

c Riveted Lap Joints. For plates of about ½ in. in thickness, the specimens averaged about 65 to 70 per cent of the strength of the unperforated plate. Typical examples of the statical strength of large specimens of riveted and welded joints are given in Table 1.

OBSERVATIONS ON EXPERIMENTAL RESULTS

1 *Static Elasticity.* It will be observed that the statical tests made to determine the elasticity indicate that, in general, the combination of welded and unwelded material behaves practically homogeneously up to at least the elastic limit. Moreover, the experiments show that the process of welding is such that the stress

is distributed practically uniformly over the weld and also transmitted uniformly to the adjacent plates.

The material of the weld is practically pure iron, and from the tests made on a specimen composed entirely of the deposited material of a weld, it will be seen that for a given stress the weld stretches slightly more than mild steel. This property will enable any undue occurrence of load being transferred in a proper manner to adjacent portions of the structure. When, however, the stress exceeds the elastic limit and is so great that the extension grows continuously without increase of load, the welded material fails sooner than mild steel. But this disadvantage is of little practical importance in shipbuilding and may be regarded as negligible in the particular problem under consideration.

2 *Dynamic Elasticity.* In a structure, such as a ship, which is exposed to variations and reversal of stresses, it is extremely important to know whether the material to be used is likely to break down rapidly under such alternations and ranges of stress as are likely to be experienced. The modified Wöhler tests employed in the experiments certainly indicate, if considered solely by themselves, that whereas for a given number of alterations mild steel would withstand a range of stress of, say $\pm 10\frac{1}{2}$ tons, the welded material might be expected to fail at about $\pm 6\frac{1}{2}$ tons, a figure which is more nearly experienced in ordinary ship construction.

As already stated, the material in the weld appeared to be nearly pure iron, and experiments of repetitive stress show that wrought iron bars are likely to fail under a range of stress of perhaps $\pm$ 7 to 8 tons as compared with mild steel at $\pm$ 10 to 11 tons. The weld has to be deposited electrically and is subject to

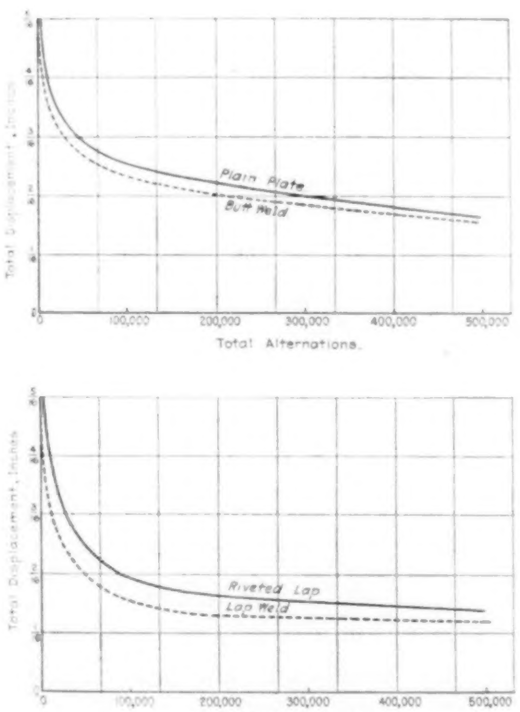


Fig. 8 Alternating-Stress Tests on Flat Stationary Plates

variations in workmanship; it would consequently be considered satisfactory if the material could withstand a range of stress of say $\pm 6\frac{1}{2}$ tons. It would appear to be necessary to design the welded joints in such a manner that the amount of work likely to be thrown on the joint is as small as possible, and to meet such a condition a welded joint must be either lapped or strapped.

Lloyd's Rules for Electrically Welded Ships

In view of the satisfactory results of these tests, the Committee of Lloyd's Register of Shipping has decided that, under certain conditions, electric arc welding may be used in the main structure of a vessel and have adopted as a tentative measure, the following provisional rules for classification in Lloyd's Register Book of vessels electrically welded, subject to the notations "Experimental" and "Electrically Welded."

Tentative Regulations for the Application of Electric Arc Welding to Ship Construction

A—System of Welding and Workmanship

1 The system of welding proposed to be used must be approved and must comply with the regulations and tests laid down by the committee.

2 The process of manufacture of the electrodes must be such as to ensure reliability and uniformity in the finished article.

3 Specimens of the finished electrodes, together with specifications of the nature of the electrodes, must be supplied to the committee for purposes of record.

4 The committee's officers shall have access to the works where the electrodes are manufactured, and will investigate, from time to time

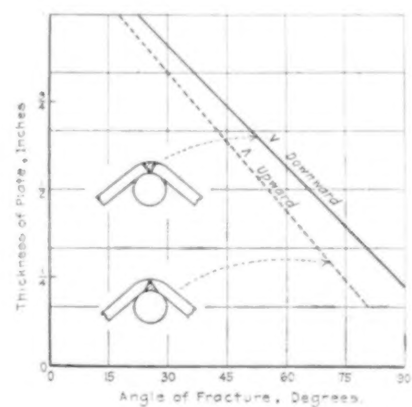


Fig. 9 Bending Tests

as may be necessary, the process of manufacture to insure that the electrodes are identical with the approved specimens.

5 Alterations from the process approved for the manufacture of electrodes shall not be made without the consent of the committee.

6 The regulations for the voltage and amperage to be used with each size of electrode, and for the size of electrode to be employed with different thicknesses of material to be joined, are to be approved by the committee.

7 The committee must be satisfied that the operators engaged are specially trained, and are experienced and efficient in the use of the welding system proposed to be employed.

8 Efficient supervisors of proved ability must be provided, and the proportion of supervisors to welders must be submitted for approval.

B—Details of Construction

9 The details of construction of the vessel and of the welds are to be submitted for approval.

10 Before welding, the surfaces to be joined must be fitted close to each other and the methods to be adopted for this purpose are to be approved.

11 All butt and edge connections are to be lapped or strapped.

12 With lapped connections the breadths of overlaps of butts and seams and the profiles of the welds are to be in accordance with the following table:

Thickness of plate, in.	*Width of overlay seam and butt, in.*	*Throat thickness, in.*
0.40 and under................	$2\frac{1}{4}$	0.28
0.60 and under................	$2\frac{1}{2}$	0.38
0.80 and under................	$2\frac{3}{4}$	0.48
1.00 and under................	3	0.50

Intermediate values may be obtained by direct interpolation, and for thicknesses below 0.40 in. the throat thickness is to be about 70 per cent of the thickness of the plate.

13 A "full weld" extends from the edge of a plate for a distance equal to the thickness of plate to be attached, and the minimum measurement from the inner edge of plate to the surface of weld is the throat thickness given in the table above.

14 A "light closing weld" is a single run of light welding worked continuously along the edge of the plate. Such a weld may, however, be interrupted where it crosses the connection of another member of the structure.

15 An "intermittent or tack weld" has short lengths of weld which are spaced three times the length of the weld from center to center of each short length of weld. Such tack welding may vary in amount of weld between a "full weld" and a "light closing weld."

16 The general character of welds is to be in accordance with the following table:

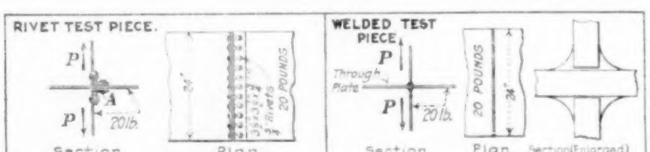
	Inside edge	Outside edge
a Butts of shell, deck and inner bottom plating .... / *b* Butts of longitudinal girders and hatch coamings	Full Weld	Full Weld
c Edges of shell, deck and inner bottom plating .... / *d* Butts and edges of bulkhead plating..	Light Weld	Full Weld
	Toe	Heel
e Frames to shell, reverse frames to frames and floors.................. / *f* Beams to decks.................. / *g* Longitudinal continuous angles....... / *h* Side girders, bars to shell, intercostal plates, floors and inner bottom..... / *i* Bulkhead stiffeners	Tack Weld	Light Weld

17 All bars required to be watertight are to have continuous welding on both flanges with tack welding at heel of bar.

18 The welded connections of beam, frame and other brackets are to be submitted for special consideration.

19 The committee may require, when considered necessary, additional attachment beyond that specified above, and the welding of all other parts is to be to their approval.

The rules are necessarily of a tentative nature and general in character and will be modified as further experience demands. It will be observed, however, that considerable importance is attached to the system of welding, type and process of manufacture of electrode, and to the employment of specially trained operators under supervisors of proved ability.



LOAD APPLIED TONS	REMARKS.	LOAD APPLIED TONS	REMARKS.
5.0	NO APPARENT MOVEMENT	50.0	NO MOVEMENT.
10.0	" " "	100.0	" "
15.0	CALKING OPENED, ONE SIDE 35/1000" OTHER SIDE 5/1000"	125.0	" "
20.0	" " " " 1/8" " " 1/8"	150.0	" "
30.0	" " " " 3/16"	170.0	" "
40.0	" " " " 7/16"	209.0	BROKE THROUGH PLATE AT HOLDER
49.0	RIVETS PULLED THROUGH ANGLE AT "A"	LIMIT OF MACH.	WELDING INTACT.

Fig. 10 Comparative Tests on Bearing Strength of Welded and Riveted Lug Attachment

Electrically Welded Vessels

The first vessel to be electrically welded so far as the writer is aware was the *Dorothea M. Geary,* a small launch 42 ft. long and of 11 ft. beam, built by the Geary Boiler Works at Ashtabula Harbor, Ohio, in 1915. The shell, which is of 8-lb. plating, is electrically welded throughout, the joints being butted and metallic-arc bare electrode used. The frames and bar keel are riveted to the shell. This little boat has been in service in the harbor since her completion, and no signs of distress or leakage have yet been noticed in any of the welded joints.

The barge recently completed at Richborough on the southeast coast of England, and referred to in the daily press as "the first rivetless ship," has attracted widespread attention. The construction of this barge was the sequence to a long series of successful tests on electrically welded joints carried out in England at the Admiralty dockyards and elsewhere, and will doubtless prove to be the stepping stone between the laboratory test stage and an actual full-powered ocean-going steamer yet to be built.

The barge in question is a non-propelled standard cross-channel transport barge 125 ft. between perpendiculars and 16 ft. beam, with a displacement of 275 tons. It differs in no way from the standard riveted type with lapped joints excepting that the seams of shell plating are arranged clinker fashion and joggled to permit of horizontal downward welding as much as possible. The hull is rectangular in section amidship with only the bilge plates curved. The shell plates are 1/4 in. and 5/16 in. thick. It was erected in the ordinary manner with service bolts spaced from 10 in. to 15 in. apart, and after the joints were welded the bolts were removed and pins driven into the holes and welded up as it was desired to complete the structure entirely without rivets.

Five welders of considerable experience were employed on the work, using the "Quasi Arc" process with flux-covered electrodes. After a few initial difficulties had been overcome, an average speed of welding of 7 ft. per hr. was maintained, including overhead work which averaged from 3 to 6 ft. per hr. Altogether there were some 7000 linear ft. of welding and 3066 holes to be filled. The total cost of welding, which was £300 ($1500), was made up as follows: Electrodes, £178; current, £60; labor, £62. It is anticipated that the large proportion of this amount represented by cost of electrodes could be reduced by some 60 per cent with an increased output.

Careful check was kept of the total cost and the total man-hours of work involved, but a comparison with that of a similar riveted barge would be misleading, since the welded vessel was purely an experimental demonstration and no attempt was made to save material or to economize by the substitution of rivets in parts where this might have been cheaper or quicker than welding. Nevertheless it is estimated that 246 man-hours were saved over the riveted barge.

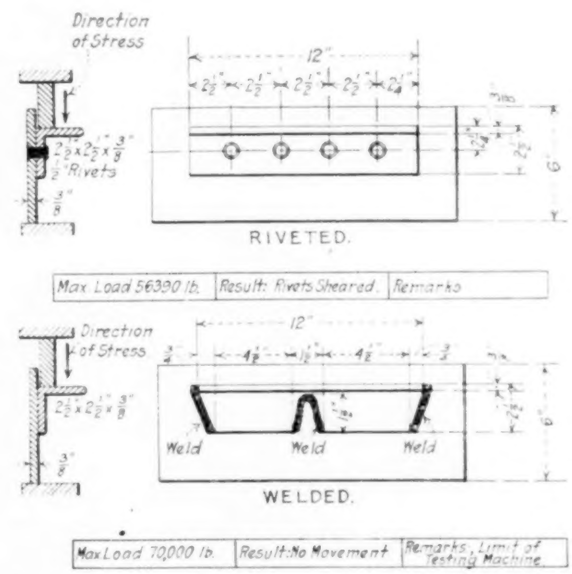


Fig. 11 Results of Tests Showing Relative Value of Calking and Welding

Since her completion she has been engaged in cross-channel service and with a full cargo of ammunition has experienced some exceptionally heavy weather, but has so far shown no signs of failure in the electrically welded joints.

Welding as an Occupation for Disabled Fighters

Apart from its importance to the shipbuilding and engineering professions, there is an impelling reason why the subject of this paper should at least command the sympathetic attention of all interested in the future of those men who in the defense of civilization have sacrificed their physical fitness to return to their former means of livelihood.

In the application of electric welding to ship construction a vast field of useful and honorable employment is opened up for temporarily or permanently disabled men on their discharge from the service or hospitals. We have seen that welding is not an arduous task; a man maimed by the loss of an arm or a leg can weld as well as the physical giant; it may be that he will weld better, for such work demands the conscientious application usually found among those whose occupations are limited as a result of physical impairment. In developing the welded ship, with all its economical possibilities, we may therefore be helped not a little by the consciousness of directly assisting in the solution of this greater problem of our national industrial economics in particular and of humanity in general.

Some Twentieth-Century Problems

By WILLIAM B. DICKSON,[1] NEW YORK, N. Y.

THE one clearly defined issue which seems to run through all history, is the eternal, irrepressible conflict between autocracy and democracy. And now America, the hope of a world grown weary with the ancient strife between democracy and autocracy, is facing anew the problem of the ages. How will she answer it? This is the theme to which I wish to direct your thoughts this evening, and I desire to say to you frankly in advance that I expect to raise some questions to which I have not been able to find completely satisfactory answers.

Let me read a recent poem by E. E. Miller:

The Question of All Time

Beside the road of time the gaunt Sphinx lay
Half buried in the dust of cities dead.
A mighty nation came with ringing tread:
The monster rose; the traveler stood at bay
And heard the riddle: "What is there to say
When idlers feast and toilers lack for bread?"
No answer came; a struggling gasp instead

Told that the Sphinx had clutched another prey
Empire on empire fell, the question still
Unanswered, and today our young land hears
It asked. She hears; her lips half apart with will
To speak; yet she is silent and appears
To halt in sudden doubt 'twixt two replies.
Still closer draws the Sphinx with baleful eyes.

My grandfather landed in Philadelphia in the autumn of 1830. He had come, in advance of his family, to see if America really was the promised land of which he had heard. He rode horseback to Pittsburgh, the journey requiring fourteen days. After spending some months in the Ohio Valley, he started back to Philadelphia on horseback in the depths of winter and suffered severe hardships in the crossing of the unbridged streams.

Not long ago, while thinking over some of the problems we are discussing this evening, I tried to picture what he would have thought if he could have foreseen the changed conditions in which his grandson would live. Let us suppose that he could have foreseen that in these latter days the journey from Philadelphia to Pittsburgh, which he made with such toil in fourteen days, would then be made in ten hours in luxurious ease. That instead of the single furrow turned by the oxteam, the food of the nation would be grown on farms where great tractors would drag a dozen plows and plow up an acre in seven minutes; and that, when the grain was ripe, it would be reaped, bound, threshed, and sacked by mechanical power, so that one man's labor would be equal to that of fifty men of his time. That instead of the slow hand process of carding, spinning, and weaving of cotton, wool and flax, great mills would be filled with power machinery that would multiply the product of man's labor a hundred fold. That all of the crude appliances of this time had been superseded by the marvelous labor-saving devices with which we are so familiar.

What would have been his conclusions as to the state of society in which his grandson would be privileged to live? Would he not have been justified in looking upon it as a golden age—an age in which the curse of poverty had been finally overcome? An age in which no honest man, willing to do his share in the community life, need ever have any apprehension of want for himself or his family? Has such a state been realized? If not, why?

Justin McCarthy, in his History of Our Own Times, tells of the horrible conditions under which women labored in English coal mines, when the seam of coal was so thin that they had to crawl on all fours for fourteen to sixteen hours a day, dragging after them the trucks loaded with coal. And this condition existed in the enlightened reign of good Queen Victoria.

I remember on my first visit to London, looking out of my hotel window early one morning in May, I saw a crowd of outcasts waiting for the park gates to be opened so that they could get in and throw their exhausted bodies on the damp grass. They had wandered the streets all night, and this was their only place of rest. I was informed that in London, on one night, as many as 35,000 homeless men, women and children had walked the streets —of whom it could be said, as was said of another outcast,—"He had not where to lay his head." And this condition was in the reign of good King Edward, and in the richest capital in the world.

Four years ago, in February 1915, as I sat down to breakfast, I opened the New York *Sun* and saw two headlines on the front page which made a lasting impression on my mind. At the upper left-hand corner was the announcement that a well-known American business man had bought four pictures for \$250,000 each, or \$1,000,000 in all. At the upper right-hand corner on the same page was the announcement that about 2000 men, women and children had stood in line the previous night in the cold rain to receive from the hand of charity a roll and cup of coffee, to keep them alive till morning. And these were not vicious men and women outcasts from society, but working people unable to obtain employment.

You will recall that this situation was so serious that Mayor Mitchel appointed a committee of prominent New York citizens to deal with this question of unemployment, of which Judge Gary was chairman.

As Louis F. Post says in his Ethics of Democracy—

> Though wealth is abundant, and wealth-producing power emulates Omnipotence, degrading poverty, and the more degrading fear of poverty, are distinguishing characteristics of civilized life. Instead of lifting all to better conditions of opportunity, man's triumphs over the forces of nature enormously enrich a few at the expense of the many.
>
> They have done little to increase the comforts of the toiling masses, even absolutely, but much to diminish their comforts relatively; and industrial liberty they have almost destroyed.
>
> The gulf between riches and poverty has not been filled in; it has been widened and deepened and made more of a hell than ever. So dreadful is the poverty of our time felt to be that it has inspired us all with a fear of it—a fear so terrifying that many more good people than would like to acknowledge their weakness, look upon the exchange of one's immortal soul for a fortune, as very like a bargain.

The Declaration of Independence proclaims as the inalienable birthright of every human being, the right to "life, liberty and the pursuit of happiness." I would like to amend the last expression to read: "the attainment of happiness," or, at least, a reasonable opportunity for its attainment.

James Mackaye has said: "Everywhere we are taught that life is sacred, that liberty is sacred, but where are we taught that happiness is sacred?" And yet, it is only because of their relation to happiness that these other things have a trace of sacredness.

You may be surprised to have me name as one of the causes of social unrest in our day the modern factory system, which we are accustomed to hear extolled to the skies as one of the most notable evidences of our progress toward a higher civilization. I confess approaching this subject with a good deal of hesitation, because it is not easy to reason this problem to a satisfactory conclusion. It is my earnest belief, however, that the man who, day after day, for the best years of his life, is a mere cog in the complex organizations which go to make up our modern factory system, is bound, in spite of himself, to be stunted mentally, morally and physically by the dreadful monotony of his task.

I have in mind such operations as wire-nail factories, where, amid the ceaseless deafening din, a man stands tending automatic machines pouring out an endless stream of nails. How much pride of achievement can be associated with such a task; or, even worse, the workers in the dust-laden, lung-destroying cement, acid, and fertilizer works?

The village blacksmith of our fathers' days who would shoe a horse in the morning and make a chain or build a wagon in the afternoon, was a better all-round citizen than the man who stands

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Address delivered before the Philadelphia Section of The American Society of Mechanical Engineers, January 28, 1919.

all day shut out from sunlight and fresh air, feeding some automatic machine, in the product of which he can have little pride. And this is not because the old-fashioned blacksmith was inherently a better man, but because of the inevitably narrowing effect of modern factory work.

I believe this very thing of which we are so proud is full of menace to our civilization, and that there was more of the joy of living among the rural population of 100 years ago than there is among a large proportion of the factory operatives today. The most important raw material of our factories is never mentioned in their system of accounting, namely, human lives and characters, but the finished product is made up of these elements just as really as of wood or steel or cotton. Cheap factory products would seem to be a vital necessity to our civilization, but if in producing them we are debasing our manhood and womanhood,—yes, and oh, the pity of it! that we must include our child workers also,—we are paying a fearful price for them.

In the mechanical arts, the world has progressed more in the past century than in all previous recorded history. If George Washington could have invited the Pharaoh of the Exodus to visit his plantation at Mount Vernon, he could not have shown him any advance in the art of agriculture over his own time, and with the exception of gunpowder, printing and the telescope, he could have shown him little or no advance in the mechanical arts. The steam engine, the cotton gin, the spinning jenny, the power loom, have revolutionized human life since then.

Most of the marvellous advances in applied science have been made in the memory of men still living,—such as the sewing machine, telegraph, telephone, phonograph, electricity in all its branches, internal-combustion engines, dynamite, airplanes and submarines.

In view of this wonderful acceleration in material progress, we should not be surprised to find a tendency toward a similar progress in the domain of human relationship, which, in some of its aspects, is as startling as were some of the inventions I have mentioned.

It is the tendency of the average business man to mistake mere inertia for true conservatism, and it is a sad comment on the power of inertia in human affairs that great advances in the science of human relationship seldom are achieved as the result of calm reasoning, but usually under the pressure of dire necessity or public danger. An English statesman once said that the British Parliament had enacted many just laws; but that it had enacted very few because they were just.

Many wonder at the social unrest which is so much in evidence, but as I contemplate recent history such as I have mentioned, my wonder is—not that men have become aroused, but that they were able so long to remain quiescent under such conditions.

In a completely natural society, every man, by reason of close and continuous contact with land and other natural resources would be an independent, self-sustaining unit. When a man has left this natural condition, whether voluntarily or otherwise, and has become the servant of another man, or other men, he has given up a natural right, and his employer has assumed an equivalent obligation. The fact that neither the employer nor the employee has been conscious of this exchange, and that both may have acted from purely selfish motives, does not alter the elemental fact, which, in the great national aggregate, constitutes the great unanswered problem of modern times; the elemental fact that is at the base of all social unrest.

The saying, "Taxation without representation is tyranny," epitomized the sentiment back of the American Revolution. Whether money is taken from a man by unjust taxation, or withheld from him by an unfair wage system, the principle remains the same. Lincoln, in one of his famous debates with Douglas said: "A house divided against itself cannot stand; this nation cannot continue to exist half slave and half free."

Political thinking has advanced with tremendous strides since then, so that as a result of the war with Germany, the nations seem ready to say: "This world cannot continue to exist half democratic and half autocratic." And while this is true in the domain of politics, it is no less so in industry. Our past history is full of instances where men in control of large aggregations of capital have been guilty of grave abuses against the public welfare and against the most elementary principles of morality. These autocrats of capital have been partly balanced (whether as an effect or a cause, would depend upon your point of view) by equally autocratic and irresponsible labor leaders, who have not hesitated to use force in its vilest forms in order to win their ends.

I do not unreservedly denounce the use of force, as to do so I would have to include in such a sweeping condemnation some of the noblest of mankind, who, as a last resort, and to redress just grievances, have not hesitated to use it. But this, which should be reserved for the holiest uses, has been prostituted by labor demagogues to achieve the most trivial ends. The only way out of this senseless conflict between capital and labor is for employers to realize that the day of industrial democracy has dawned, and that "The establishment of wage rates and other conditions of employment without representation is tyranny" also.

Much has been done by benevolent employers to improve working conditions, but however conditions may be improved, the right of the workmen to collective bargaining must be recognized as a legitimate outgrowth of American ideals. The individual workman, dependent on his own strength and resources, cannot hope to bargain on equal terms with the corporation. If he cannot do so, and is debarred from association with his fellow-workmen, he is no longer a free man but a serf: and the serf has no place in the future of America.

Many years ago a noted steel man was asked which was the most important factor in his business, labor, capital, or management. His reply was in the form of a question: "Which is the most important leg on a three-legged stool?" While the above conclusion as to the equality and interdependence of these three factors has been generally accepted as a theory, in very few instances has it been given practical effect.

I believe that the greatest task to which American employers must address themselves is the devising of practical ways in which labor can be given the full recognition to which, as an equal partner, it is entitled. I make this statement with absolute confidence in the fair-mindedness of the American workingman when he is fully informed and is entirely free to act. If I did not have this confidence, I would despair of the future of our free institutions. I believe that one of the first steps necessary to inspire the workmen with confidence in the sincerity of the employers' recognition of the proper status of labor is the adoption of a fair system of collective bargaining. I am glad to say that the company with which I am connected has recognized this right, and has established what I believe to be the most democratic system of collective bargaining which has ever been devised.

Some of you may ask what is to become of the sacred freedom of contract under such a system? I answer—The same thing which has happened to many other seeming natural rights which the individual has sacrificed for the common good.

Consider for a moment the natural rights which you have resigned as compared with the residents of Philadelphia only two or three generations back. Can you imagine some doughty individualist of those days submitting suddenly and gracefully to all of the laws and ordinances of the municipality, the state, and the Federal Government, to which you give not only obedience, but also assent? Would your great-grandfather have tamely submitted to compulsory vaccination, to restricted child labor, to the haughty traffic policemen and your one-way streets; to all of the restrictions on your personal liberty which you recognize as essential to the common good? None of these questions can be answered separate and apart from the problems of our complex civilization.

I also believe that as a further natural development of democratic ideals, systems of profit sharing with employees must be worked out and adopted. One of the earliest records we have of the employment of one man by another for wages, is that of an Arabian sheik who employed a young man to care for his flocks. It is interesting to note that while at first he was a mere hireling, the relationship eventually changed into one of profit sharing. I refer to the story of Laban and Jacob as recorded in the thirtieth chapter of Genesis. If you look this up and find that the em-

ployee "put one over" on his employer, I hope you will not on that account condemn the principle.

No system could be devised which would be applicable to every industry, but this basic principle would be common to all. Capital can, with reasonable care, be invested so as to return, say, 5 per cent, with little or no risk to the principal. Where it is invested in a business where risk of depreciation or loss of the principal is a constant factor, as it is in most industries, it should have the first call on the profits to an amount in excess of 5 per cent to fully cover this risk. This percentage would, of course, differ widely from that of national bank stock up to the manufacture of explosives. If I were asked to suggest a tentative plan for the average well-established steel company, I would first give the stockholders 10 per cent on their stock and divide the surplus over this amount equally between the stockholders and the employees, including the management.

In other words, capital, management and labor are each entitled to wages at current rates, and to a sufficient share of the profits to insure permanency. Capital, under the example cited, would receive 5 per cent as wages and an additional 5 per cent as insurance. Management would receive salaries which, presumably, would be large enough to enable each person to avail himself of modern life, accident and health insurance. Labor would receive wages at current rates and would be insured by the workmen's compensation law, maintained by taxation of industries. After the payment of these wages and insurance, the remaining profit should be divided equally between capital on one hand and management and labor on the other.

And now, in conclusion, in what spirit shall we deal with these problems—that of class consciousness, or in that broader spirit of human brotherhood which is so gloriously set forth in the writings of the loving-hearted Lincoln—"With malice toward none—with charity for all"?

Herr Ballin, one of the wisest of the former counselors of the Kaiser, in a recently published letter ridiculed the idea that Americans as a nation were mammon worshippers, and expressed the opinion, based on long years of close business association, that we were, on the contrary, above everything a nation of idealists. To prove that this has been true in the past, we need only to point to the Civil War, waged for the great ideal of human freedom; the part we played in the Boxer Rebellion, in returning to China our share of the indemnity exacted from her; the Spanish War, to end the intolerable conditions in Cuba and to establish her as a self-governing nation; and lastly, our part in this great war in the defense of civilization, in which we engaged technically, perhaps, because our legal rights were violated, but in fact because we recognized that it was a death struggle between autocracy and democracy, and one in which the leading democracy must play a noble part or be forever put to shame.

And in this holy war, in which the ideals for which America stands have been so gloriously triumphant, the sons of employers and workmen have marched shoulder to shoulder, and many of them sleep together today in the same patriotic graves in the soil of France, hallowed by their sacrifices. Let us, in the same spirit of brotherhood, grapple with the problems of peace and help to usher in the dawn of an industrial democracy which will give fuller recognition to the thought expressed by Burns:

> The rank is but the guinea stamp.
> A man's a man for a' that.

The speaker prefaced his address with a brief statement of his experience in order to show that he had at least had the opportunity to study certain present-day social problems at close range. Starting when a boy as a manual worker in the Homestead Steel Works, he had been fortunate in receiving rapid and continuous promotion, and eighteen years later had become one of the junior Carnegie partners. He had been vice-president of the U. S. Steel Corporation for the first ten years of its existence. In 1915, after a brief retirement, he had returned to active business life as an officer of the Midvale Steel and Ordnance Company.

He had been reproached for his attitude on social questions by his friends and associates, and had at one time or another been called a socialist, an anarchist, a Bolshevik, a radical. He was glad to be termed the latter, however, provided that Gladstone's definition was accepted:

> Conservatism—Distrust of the people, tempered by fear.
> Liberalism—Trust of the people, tempered by prudence.
> A Radical—A Liberal in earnest.

He wanted to disclaim being a mere sentimentalist. He had had to deal with hard facts all his life, and he believed that he was able to keep his feet on the ground, even if his head might seem to be in the clouds.

Readjustment of Labor

THE Readjustment Committee of the Merchants and Manufacturers' Association of Baltimore has rendered a report on the labor conditions in Maryland. A brief summary of their remarks and suggestions, which were classified under 11 different headings, is as follows:

1 *Right kind of man can get a job.* Employers now are not driven to the extremity of submitting to any kind of labor as during the war, and they can expect in return for a high wage an equal measure of productiveness.

2 *No use to look for war wages in normal shops.* Times are normal again and workers cannot in reason expect the excessively high wages of munition and other war plants.

3 *Must beat down the high cost of living.* Alliance of capital and labor is absolutely essential to bring about a reduction in food prices.

4 *How about the soldier laborer? How could he be handled?* Proximity of military places to Baltimore causes many of the discharged soldiers to pass through the city on their way home. They plunge into pleasures and accompanying excesses and find themselves stranded. Then they look for work under conditions to their disadvantage. This demoralizes the labor market.

5 *Must reëmploy resident returning soldiers.* It is suggested that the public, through some community committee, should be apprised of all those employers who turn their backs upon the men who responded to the call of their country.

6 *What to do to take care of the unemployed.* If unemployment becomes ominous, it becomes a community problem, and the state, the city and the counties should work out plans for public improvements and should offer work to those who might otherwise suffer.

7 *Women workers who do not have to work for a living.* If these women were induced solely by patriotic motives to take jobs during the war, why will not the same lofty patriotism, in times of peace, induce them to surrender the jobs in favor of men and other women whose families will go hungry if employment is not found?

8 *Returning munitions and shipbuilding laborers vs. out-of-town soldiers.* During the urgent days of the war great patriotic drives were made all over the country to make workmen understand that it was their primary duty to give up all else in order to promote rapid making of munitions and the speedy building of ships. That being true, the munition worker or shipbuilder who seeks a return to his old employment under terms and conditions commensurate with the peace situation is entitled to consideration ahead of the out-of-town man in uniform.

9 *Not fair to fill the places of local labor with soldiers who belong elsewhere.* The committee is of opinion that when a nonresident soldier makes application for employment to a local United States Employment Service, that Service should endeavor to place him at work in the city or state from whence he came.

10 *Industry should not drive labor into the arms of dangerous allies.* Only a genuine coöperative relationship between industrial employers and labor can prevent a closer alliance of the Non-Partisan League, an organization of radical agriculturists, with industrial labor. Narrow-minded policies of American employers will precipitate the spread of the socialistic tendencies that have gripped North Dakota.

11 *How to make high wages certain.* Employers are willing to pay an average wage to an average worker, but why should not the worker be allowed to progress in the range of his wage earnings in proportion to his individual productive powers?

The Engineer as a Citizen

A Symposium on His Civic Responsibility and Relation to Legislation, to Administration, to Public Opinion and to Production and Distribution

A WELL-ATTENDED meeting of engineers of the metropolitan district was held on the evening of March 26 at the Engineering Societies Building, New York City, the purpose of the gathering being the discussion of the place and duty of the engineer in the community. The meeting was held under the general auspices of the New York sections of the national mining, mechanical and automotive engineers' societies, and the members of fifteen other engineering and chemical societies were invited to attend and take part in the discussion. Gano Dunn presided and introductory addresses were made by Philip N. Moore, Calvert Townley, Nelson P. Lewis, Spencer Miller and Comfort A. Adams. An active and extended discussion followed, one important result of which was that resolutions were adopted looking to the organization of a New York local engineering society composed of the local sections of the national societies and of other local engineering organizations. Abstracts of the addresses and the discussion which followed their presentation are given below.

The Civic Responsibility of the Engineer

Philip N. Moore

The engineer, waking from long sleep of indifference and self-content, satisfied with himself in his professionad successes, has suddenly waked to the fact that he is not politically potent. He has not counted as a class politically because he has not served politically; he has not, save in rare cases, developed in himself the political sense. In the professional heart-searching, momently the dominant mood, he seeks the reason.

Broadly speaking, the answer is plain. He has not cared enough to exert himself personally or professionally to attain an end which now at last seems to him worth while and vital.

Given like heredity and culture, there is no inherent reason why an engineer should react differently from any other citizen to the patriotic call or civic responsibility. But, unfortunately, things have combined to leave him too often unwanted and uncalled. What are these things?

First, lack of local attachments. With few exceptions, the engineer's tasks are scattered countrywide, or worldwide, and mostly are those of construction, which, completed, he goes his way to build again. He works under strain, he has little time to forgather with his fellows, or to think in terms of political or national interest and service, save as great emergencies come, like that of the late war. And without local responsibilities a man feels little sense of civic duty and finds less opportunity for participation in national questions.

Second, a large proportion of the total body of engineers serve the great business consolidations, many of which have interests adverse to the public, or by their very size induce criticism and political attack, and in self-defense they think they must hold their staffs to strict neutrality on all public questions.

Third, the engineer's training has failed to teach that the greatest task of all is the ability to persuade men, and unwillingness or incapacity to enter public discussions, either through modesty or lack of readiness, have held him back. False professional pride, and the same indifference which holds back many high-class men through unwillingness to mingle with and rub shoulders against the great majority, have also deterred him.

Fourth, the past habits of the great organizations which the engineer forms (and which voice his profession) to hold themselves aloof from political affairs as collectively unethical.

What shall be the remedy for the engineer's isolation? It is within himself. He must realize that the duty is in him first and then in his society. By virtue of his exact knowledge of the things which build so large a share of civic affairs, for so much is engineering, he is particularly fitted to render expert advice and service.

We need fearless men who in the market place and from the housetop shall proclaim to the world: That since the beginning of history brains have ruled brawn; that the brain deserves, and in the ultimate will inevitably receive, greater reward than the hand; and that any proposed condition which puts brawn over brains plans the pyramid on its apex and necessarily is one of unstable equilibrium.

These are a few of the things we can preach, and because we fear no political backfire. We have no fences to mend. We can stand in the open and say everlasting truths, and the time will come when some men may believe them.

The Relation of the Engineer to Legislation

Calvert Townley

What the attitude of the engineer should be toward legislation is a question that has been debated with considerable vigor for many years. Opinions differ widely, and range all the way from that of the ultra-conservative, who believes that the engineer should have nothing whatever to do with legislation or politics, to that of the ultra-radical, who thinks that he should direct all legislation—in fact, that no government function should be exercised except under his direction.

It may help us to visualize the present situation if we examine briefly one or two of the ways in which engineers have attempted to influence legislation heretofore. In 1911 the American Institute of Electrical Engineers, on invitation from the National Waterways Commission, sent a committee to Washington to appear before the Commission. The committee was assisted by a special advisory committee, and held several meetings before proceeding to Washington in order to determine just what should be their policy and what sort of a presentment they should make. It was decided that the committee should confine itself strictly to a statement of engineering and allied facts which engineers were peculiarly competent to testify and which were beyond the field of controversy. They were instructed to refrain from expressing views as to the wording of any legislation or to give opinions regarding legal matters.

In 1911 a bill was introduced in the New York state legislature to license engineers and which aroused the alarm and stirred up the strenuous opposition of the four national engineering societies. A joint committee was appointed from these societies, and from the Institute of Naval Architects and Marine Engineers as well. This committee sent a strong representation to Albany, which appeared before the Legislative Committee and vigorously opposed and assisted in defeating this attempted legisla ion. It was found desirable to take somewhat similar action again in 1913. Feeling that it would be advantageous to have some means of coöperation among the national engineering societies, this committee was continued under the title of a Joint National Committee of Engineering Societies and continued to serve for several years, its activities, however, not by any means being confined to legislative matters. One of its functions was to serve with respect to the National Engineering Congress held in California in 1915, and out of it grew the discussion which finally resulted in the organization of the Engineering Council.

The Engineering Council has been in existence since May 1917. It has been in receipt of many requests to favor or oppose legislation, and this legislation is by no means confined to questions of engineering, but covers every sort of subject from the fixing of a minimum wage for labor up to the organization of the Army for the conduct of war.

The Engineering Council was created to speak for its constit-

uent societies on matters of common concern to engineers and to afford a means for joint action when desirable. Its by-laws give it wide latitude, and there have been no limiting instructions issued to its delegates by the appointing bodies. The Council has therefore had to determine upon its own line of action, and it is by no means certain what that should be with respect to legislation.

It has been my lot to have to do with this question for a number of years, and while I have earnestly sought to get the opinions of my engineering friends and to act upon them, I confess that I do not know what engineers want, and therefore what our policy should actually be. Of course, we believe in ourselves. We believe that an engineer's training, designed as it is to make him think clearly, to deal with essential facts and to arrive at logical conclusions regardless of outside influence, peculiarly qualifies him to express opinions on legislative as on other subjects, but we shall have to choose which of two places to occupy. Shall we be a united body of technical men, speaking only with deliberation and a certain amount of proper dignity regarding subjects which the public recognizes us as qualified to speak upon, or shall we be as a body of somewhere from 30,000 to 100,000 citizens who have a common interest and desire to exert political pressure by reason of our numbers?

I would like to think that we could combine these two positions, but my logic tells me that we cannot. Personally I believe we should not try to influence legislation which concerns us only as citizens, but if we undertake the task at all, we should concentrate our efforts on certain specific lines and thereby stand a better chance of having them prove effective.

The Relation of the Engineer to Administration

NELSON P. LEWIS

Heads of great industrial enterprises, transportation companies, and all other public-service activities, are required to perform functions which are largely administrative. Such places were once almost always filled by business men or lawyers; later by men who had come up from the ranks, hard-headed men who had begun as boys and passed through the various branches or divisions of the work and had demonstrated qualities of men, leadership and executive capacity, but seldom were they of technical education. During recent years, however, we have seen such places more frequently filled by men who knew the science as well as the art of the business, keeping in mind the old distinction between the two, namely, that science teaches us to know and art to do. There have been many conspicuous instances where spectacular success has been achieved by young men of this type, a success which would only have been gained under the former system through long service, beginning at the very bottom and slowly mastering the details.

But the term "administration," as commonly used and understood, relates more particularly to public business; business of the city, state and nation. From this type of administration the engineer has been more completely excluded than in the case of industrial concerns or public-service corporations. In this exclusion the engineer himself has appeared to acquiesce. He has been so long accustomed to doing things when he is told, as he is told, and because he is told by those whose function he has thought it to be to determine general plans and policies that he is in no small degree responsible for the idea which has been generally prevalent, that the duty of the engineer is simply to carry out the ideas and policies of others. But if it be admitted, as it must, that what is commonly called the administration of public business is largely the formulation and execution of engineering projects, why should not engineers themselves take a conspicuous part in their formulation as well as their execution?

The machinery of municipal administration, as prescribed by city charters, has usually been very cumbersome and ill adapted to meet emergent conditions. In 1900 the city of Galveston was practically wrecked by a violent storm and tidal wave. The city was already in a bad financial condition and the municipal government was unable to cope with the situation. In order to meet existing conditions, a form of commission government was adopted under which the entire management of the city's affairs was placed in the hands of five men. So successful was the plan that within a dozen years it had been adopted by about four hundred cities and towns within the United States.

In 1913 the city of Dayton went a step further and adopted what is known as the commission-manager plan. This also consisted of a commission of five citizens, elected at large, who constituted the governing body, but they appoint a chief administrative officer, designated as the city manager. It will be noted that these two forward steps in municipal government were taken by cities which had suffered great disasters.

Thus was developed a public office which the engineer with executive capacity is especially well qualified to fill, and that this opinion is held by those responsible for the selection of the managing executives is evidenced by an examination of the list of city managers who have been appointed. Of the 124 cities now operating under some form of the city-manager plan, the speaker has been able to secure information as to the previous experience and training of 88 of the managers, the classification being as follows:

50 professional engineers
9 merchants
6 minor city officials
5 general business
3 superintendents of construction
2 journalists
13 miscellaneous (these including one each of contractor, railroad president, railroad purchasing agent, public-utility manager, professor of government, training school for public service, office manager, league secretary, real estate, lawyer, physician, broker and plumber).

But what about the training of the engineer to fit him for such positions? Business sense is certainly an essential qualification for success in such work as the management of a city, a public-service corporation or an industrial enterprise. Are the courses given in our engineering schools calculated to fit him for these most attractive fields of activity? We will be told that all of the time of the student is required to enable him to cover the strictly technical curriculum, and that if such things as culture and business courses are to be added, the period of training will have to be lengthened or some of the technical courses will have to be curtailed or omitted. Perhaps this would not be as serious a loss as professional educators imagine, while it would broaden the student and might account for the difference between success and failure in administrative positions.

The Relation of the Engineer to Public Opinion

SPENCER MILLER

The engineer is assuming an ever larger position in public life, and in spite of himself he is at the very center of life. The more we realize this great truth, the more seriously do we contemplate our responsibilities. This thought fills some with pride and others with humility. Eliminate the engineer from the world and civilization would soon pass through other Dark Ages comparable with savagery and barbarism. It is clear, therefore, that we, individually and collectively, should make every possible effort to mold public opinion in the right direction, especially at present to counteract the propaganda of those stirring up class hatred. Even today the engineer stands, with all law-abiding citizens, facing the dark cloud of Bolshevism—not timidly, not indifferently, but in full strength, courage and faith that Bolshevism cannot survive in America because it stands squarely against the code of morals upon which our civilization was founded.

We observe that the engineer is successful in public life because of his technical training and his upright character. But who may say that a well-trained lawyer with upright character to his credit would not make an equally good public servant? Is it not evident that both engineer and lawyer are needed in public and political life and are any comparisons advantageous?

A Congress half lawyer and half engineer surely would be superior to one all lawyer or all engineer. Do we not also recognize

that experienced business men, manufacturers and farmers of upright character are also required to serve the nation in Senate and Congress?

What is the relative importance of the training of an engineer as one element and his upright character as the remaining element? Let us look for an answer in the recent struggle to find that element which President Wilson so aptly called "the very stuff of victory."

The program for the United States involved billions upon billions of money. Ships by the thousands, airplanes by the thousands, guns by the hundreds of thousands, shells by the millions, tanks in hundred thousand lots, and several million men besides. A small fraction of these materials of war ever arrived in France, and yet both France and England frankly acknowledge that our troops turned the scales against Germany. What, then, is the answer? Who won the war? What won the war? The answer to the riddle is the same that Napoleon announced one hundred years ago: "The relation of morale to materials of war is as three to one." And Marshall Foch only last week said, "Faith won the war." Both faith and morale are things of the spirit. If the stuff of victory at arms is largely a thing of spirit, why is it not also true of any victory in engineering. Are not the greatest engineering victories due more to perseverance, industry, good habits, courage, pluck, steadfastness than to simple engineering training? Is it not the spirit, after all, that wins all victories?

If the engineer finds that in the complete fulfillment of his life work about one-quarter is material and the remainder spiritual, should not engineering societies make adequate recognition of this important fact? Is not morale as important to the engineer as to the soldier? Is it not as important to an engineering association as it is to a military division? If these facts are conceded, then can we refuse to give the fullest and most complete consideration to the development of these traits among engineers?

The Relation of the Engineer to Production and Distribution

COMFORT A. ADAMS

Two of three of the speakers have spoken of engineering education, and the last speaker spoke of matters of character and spirit. I have long been concerned with engineering education, and certain things have been impressed very vigorously on my mind, and one of them is that it is not the curriculum and the subjects that are taught that count; it is absolutely and solely the way in which they are taught. That is really a conviction so strong in my mind that I am not concerned with the subjects that are taught, but vastly concerned with the men who teach them.

Coming now to the subject assigned to me on the program, let me say that the civilized world is today facing a crisis second to none within the memory of this generation or of many preceding generations. Discontent is rampant throughout the proletariat in many European countries, and is spreading rapidly in our own.

The situation may be stated roughly as follows: Labor feels that in the past it has not had its fair share of the wealth it has helped to create; it wants, is beginning to demand, and in some instances is getting so much, that the balance will soon be a minus quantity.

What are we going to do about it? Shall we sit tight, and because we are comfortable satisfy ourselves by criticizing vociferously the discontented because of their unreasonable demands, or shall we use our brains and training and at least to try to remove the cause, and to meet the situation intelligently? We are engineers, and the machinery of production and distribution is largely of our making and largely in our hands; is it not possible that this machinery can be so improved as to increase the productivity of labor and thus make possible a really living wage and still have a fair return for capital?

"But," I hear you say, "that is our normal job—we are doing that all the time, and as rapidly as possible; moreover, the United States already leads the world in that direction."

In answer may I point out a few facts: First, our industrial success has been due in considerable part to our enormous natural resources, the cream of which we have been squandering in prodigal fashion, and also in part to our exploitation of cheap foreign labor, for which exploitation we may have to pay a very high price, as it is in that group that most of the active discontent is found.

Second, in many of our old established industries there still remain many grossly inefficient, almost traditional, processes which we accept without thinking, because "it has always been done that way."

Third, and this is my chief point, there still remains an almost untouched field of possibilities in the elimination of our present excessively expensive system of competition.

One instance of this wastefulness which has come under my close observation during the past year is in the field of electric welding. Here a dozen or fifteen manufacturers were each found selling welding apparatus under claims relating solely to the characteristics of the electric machine which supplied the current. The claims were so conflicting that no ordinary purchaser or customer could possibly come to any sane conclusion as to the best apparatus to purchase. And, as a matter of fact, even of all the factors which go to make up a good weld, the characteristics of the electric machine are practically of the least importance.

I can cite specific instances in this field where the cost of accomplishing a certain result was two or three times as great as the reasonable cost might well have been, and others in which the whole expense involved was practically thrown away; and although the problem of the electric weld is not a simple one, still information was available and knowledge was available of the art which, if collected together, under any reasonable coöperative system, would have largely eliminated the wastefulness mentioned. In other words, the answer to this problem is well covered by the one word "coöperation"—coöperation in research, in standardization, and even in some cases in design.

The chief obstacles to this are traditional fears as to the loss of independence and initiative, and the distrust of our competitors. I only wish that I might by some telepathic process convey to you my firm conviction after some experience, much thought and study, that these fears are largely ungrounded, that the result of such thorough-going coöperation as here urged is sure to be a gain to all concerned, and that under such a system real merit would prevail even more than now.

Finally, may I add a plea that we engineers, whose normal work is so much concerned with organization in industry, accept as a part of our responsibility as citizens the broader problems relating to the organization of society, that we face the facts fairly and prepare to take an intelligent step forward, rather than wait until the great tank of discontent has gained momentum enough to crush us and all that we represent.

DISCUSSION

S. N. Castle, who opened the discussion, said that the speakers had truly voiced the feeling instinctive to the engineer—the desire to serve. But to enable him to serve others, he must first serve himself. At present a hedonist in his individualism, he must learn to present, as an engineer, a single and united front.

This must undoubtedly come through organization; but how? what? Highly differentiated though the engineer might be, the lawyer was far more so; yet he spoke as with one voice—as a lawyer, and with and through his bar association. Soo, too, did the merchant who also had his associations and chambers of commerce. The engineer, however, still talked confusedly, with many tongues.

The problem, he believed, was susceptible of four general solutions: (1) A merger of the existing societies into a single national organization (with such local sections as appear desirable) capable of serving equally all technicians, whether artisans, mathematical engineers, applied scientists, or research scientists; in other words, create definitely an Institute of Industrial Sciences; (2) a New York engineering society or metropolitan association of engineers, comprising the New York section of the national societies and local engineering societies; (3) a joint engineering council, to be composed of definite delegates from

the New York sections or local societies; and (4) interlocking committees in the national societies.

Daniel Turner, in discussing Mr. Castle's recommendations, urged that no new organization be formed, inasmuch as a suitable organization already was in existence.

"Why not let the American Association of Engineers become the standard bearer of the affiliated and united engineering societies?" he said. "Why not help to establish its destinies? Why start another organization, which means more differentiation and still further dispersion of our energies? Service is one thing, being servants in the situation is quite another thing. The logic of the situation points inevitably in one direction—there is only one answer: In squads, all of our efforts, just as in the past, are doomed to fail; as a great army of engineers we would be irresistible."

Frank Skinner believed that the national and local methods proposed by Mr. Castle could be combined. There were already several hundred different organizations for the 50,000-odd accredited engineers of the country, and he urged a federation of these rather than the formation of a new body in which the rivalries and just pride of the now existing societies would be lost. The engineer was he who actually carried to successful fruition the work of the designer, the mathemetician and the pure scientist, and the Association of General Contractors of America, recently formed in Chicago, he believed was better adapted to deal with their necessities than any precedent organization.

J. E. Johnson, Jr., made a plea for a change in the curricula of the engineering schools in order that more attention might be paid to the human side of engineering and to the subject of finance. In the matter of organization he believed that both the national and local societies had their proper place in the scheme of things. The Engineering Council was an associated activity that should be endowed with greater power, made more national in its scope and composed of men who would do their full share of the work.

H. A. Pratt told of the effective work carried on by local associations of engineers of all branches in San Francisco, Cleveland and Philadelphia, and urged strongly a similar organization for New York City.

Lieut. George S. Van Gilder expressed the opinion that the whole situation could be analyzed as a feeling of unrest. No doubt, he said, the engineer had occupied a very insular position toward society, and the crisis of the past two or three years having gone by, he was now confronted with a new crisis which he feels intensively, but is hardly able to express.

The unemployment problem might easily become a menace, and his suggestion was that each engineering society organize a unit for the purpose of studying sociological questions from an engineering standpoint, and that a council of these units be formed for the discussion of the problems arising at the different local branches.

In order that some definite action might be taken as a result of the meeting, C. F. Scott offered the following resolution, which was later adopted:

Whereas, All engineers, as citizens, should invite the fullest coöperation; and

Whereas, Complete coördination of the engineering profession, as a whole, is essential for the best interests of the community; and

Whereas, It is the sense of this meeting that some program be formulated whereby closer coöperation between engineers may be obtained; therefore, be it

Resolved, that the Secretary of this meeting be and is hereby directed to so notify the secretaries of the several societies or local sections of the societies here represented tonight with the request that the several secretaries transmit this resolution to their respective local membership, together with an invitation to said local membership to appoint a delegate to attend a joint conference, with a view to organizing so as to obtain closer coöperation between engineers, particularly between the engineers resident in the Metropolitan District, whereby they may become more potent in fulfilling their responsibilities as citizens.

C. A. Doremus, a member of the Société de Chimie Industrielle and the Society of Chemical Industry, while not officially representing these societies, was nevertheless of the opinion that they would coöperate in any movement to make the engineering professions and scientific pursuits of more weight and greater influence.

Jesse M. Smith, one of the charter members of the American Institute of Electrical Engineers and a past-president and one of the earlier members of The American Society of Mechanical Engineers, spoke of the constantly increasing coöperation of the four national societies brought together in close relations through the United Engineering Society. Up to the present time this society had been scarcely more than a holding corporation, but its constitution was such that engineers of all branches might come together under its organization. A single society for the engineering profession seemed to him inevitable.

At the request of the chair a letter from H. H. Vaughan, of Montreal, Canada, was read, which briefly outlined the organization of the Engineering Institute of Canada. This society is composed of engineers belonging to all branches of the profession, and is the only national engineering society in Canada. Its organization is such that the society can represent the engineers with equal ease in city, town or province, or, if necessary, all the engineers in the Dominion.

Farley Osgood thought that the principal reason why engineers were not more generally accorded recognition was their own individual lack of interest in outside things. This was particularly true of young engineers, and he believed if educators were to teach them as much of a curriculum as was necessary, and also find out what the minds of the various young men might be adapted to other than engineering, that they would help them broaden themselves along these lines also, so that when they started out in the practice of their profession they would carry in parallel with it some civic work, some outside interest.

As an indication that the subject of the evening was one receiving nation-wide consideration, Philip N. Moore called attention to the work of the National Service Committee of the Engineering Council. "This Committee," he said, "has taken as its first task one which is unanimously welcomed by the engineers of the country as a great public need, namely, the establishment of a National Department of Public Works, where under one head the different engineering functions of the United States can be correlated and which today are scattered under twenty-two bureaus and six cabinet officers. In undertaking that task, the National Service Committee has called a meeting of delegates from all the engineering societies of the United States of which they can learn the existence, and requested them to send delegates to a meeting in Chicago, April 23 to 25, prepared to discuss a concrete, definite plan for the establishment of a National Department of Public Works. Through one of the secretaries of one of the organizations a questionnaire has been issued to all of the organizations interested on which they request organization action.

"Further, I happened to learn in Washington that the idea itself will be more than gladly welcomed. That meeting of engineers in Chicago will probably be the most representative meeting of engineers ever gathered together in this country. From it your speaker personally feels that there will come great good, and it is a great deal of pleasure for him to tell you of it in advance of the public statement of the meeting, because it may have some influence on your decision in the matters now here before you."

Louis C. Marburg, Chairman of the A.S.M.E. Committee on Aims and Organization, said that the problems under discussion were so great that the four national societies had appointed committees on development and on aims and organization to secure, if possible, a crystallization of opinion as to what the ideals of the engineering profession and the ideals of the engineering societies should be. There were hundreds of engineering societies in the country and an utter lack of coördination between them as to their efforts along lines of public service and public uplift. The discussion of the evening should be spread everywhere, it should be taken up by all the national engineering societies and by all the local engineering societies. The crystallization of ideas as to what the purposes and aims are to be must be secured before the machinery for carrying them out can be proposed. To this end he offered the following statement and resolutions:

Around us is a world on which, during the past two generations,

(*Concluded on page 496*)

ELECTRIC ARC WELDING

By F. A. ANDERSON,[1] SAN FRANCISCO, CAL.

IT is only a few years ago that the subject of electric arc welding would have aroused but little interest, and yet today the art is engaging the attention of many men standing high in the engineering profession.

At the present time electric welding may be divided into two general classes, resistance welding and arc welding. The former had its inception some thirty years ago, and has been practiced more or less continuously ever since, gaining in popularity as its many applications have proved themselves valuable.

In this process the necessary heat is produced by current flow through the high resistance of metals in contact, and when the proper heat is obtained the completion of the weld is accomplished by the application of pressure sufficient to unite the molten masses into one. This is the fundamental principle of the many spot- and butt-welding processes in use today.

Arc welding is about twenty years old and was probably first introduced by Zerener, who devised the means of holding two carbons of opposite polarity in a V form and employing an electric magnet for forcing the arc toward the work. The desired heat was thus obtained directly on the metal to be welded, and welding wire was fed into the arc, filling the void and completing the work. This early process resembled that of the acetylene torch and is rarely used today.

The next improvement in the art was due to Bernardos, who dispensed with the electromagnet and one carbon, using instead the work as one side of the circuit and a carbon as the other. The arc was struck directly on the work, immediately producing the desired heat, and at the same time the welding wire was fed into the work. This process is still extensively used and lends itself most advantageously to many phases of modern practice. It is generally referred to as carbon welding.

A further development was made by Slavianoff who introduced the method of using the welding wire for both striking the arc and feeding it into the work. As a result the welding wire became known as the electrode, and the process as metal-electrode welding. It is one of the most generally used today and whenever discussing it the term "electrode" refers to the metal added in the operation and the term "parent metal" to the metal to be welded. In recent years the term "arc welding" has been understood to mean metal-electrode welding, and it is generally customary to qualify the phrase when referring to carbon welding.

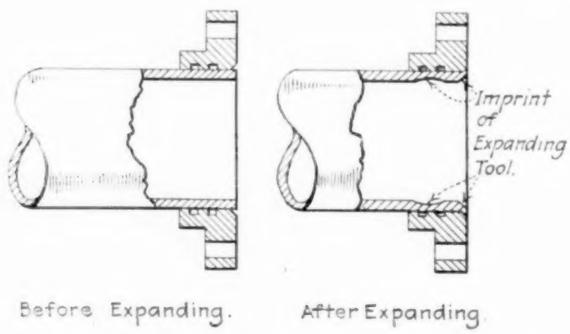

Fig. 1 Method of Expanding Pipe into Flange

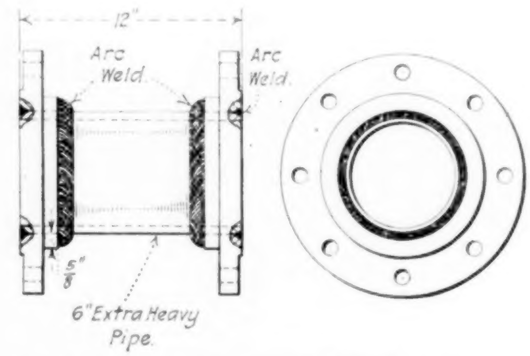

Fig. 2 Welding Required on 6-in. Steel Flange

In the past a great many failures of welds have been largely due to the operator, who did not manipulate the electrode so as to bring the parent metal to a molten state. This resulted in the electrode being deposited on but not uniting with the parent metal, since no pressure is added to complete the union.

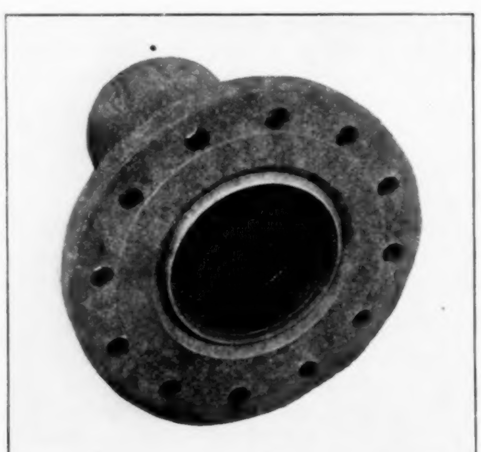

Fig. 3 Pipe End and Flange, Ready for Welding

Fig. 4 Pipe and Flange with Weld Complete

As an example of one such failure, the following may be of interest. A short time ago the writer was connected with an enterprise where difficulty had been experienced in successfully expanding 6-in. extra heavy pipe into steel flanges. Fig. 1 shows a section through a flange, with the pipe in place before and after expanding.

This method, however, proved unsatisfactory. Both the screwed flange and the Van Stone or flanged joint had also been

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Abstract of a paper presented at a meeting of the San Francisco Section of The American Society of Mechanical Engineers, February 13, 1919.

[1] Electric Inspector, U. S. Shipping Board

disapproved, and when arc welding was suggested the writer was asked to make a sample for test.

Fig. 2 shows the welding required and Fig. 3 the pipe with one flange in place and the end of pipe beveled to form half the V for the arc-welding operation, the other half of the V being formed by the original bevel provided on the flange for the intended expanding process. Fig. 4 shows the welding operation completed. It will be noticed that the operator has overfilled

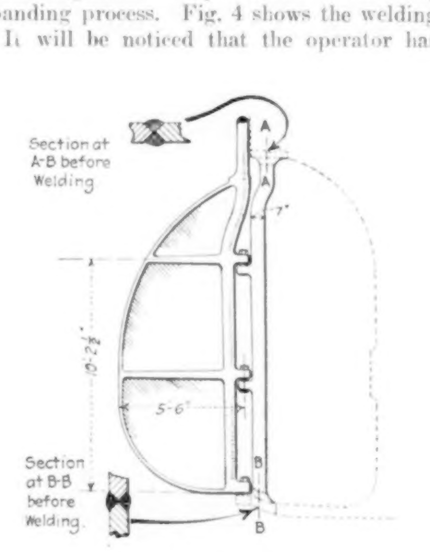

FIG. 5 RUDDER POST REPAIRED BY WELDING

the V on the face of the flange, thus making it necessary to machine the fitting.

It is still generally believed that the metal in passing through the arc loses all its ductility and elasticity and assumes characteristics wholly those of cast iron or steel. The turnings of this weld, however, presented an appearance similar to good machine steel, and when analyzed showed the following: Silicon, a trace; sulphur, 0.075; manganese, 0.23; phosphorus, 0.0018; carbon, 0.25.

While it was essential that this weld be able to stand a steam pressure of 200 lb., the sample was tested first at 500 lb., then at 800 lb., next at 1000 lb., and finally the pressure allowed to go the available limit of 1400 lb.

This test was witnessed by a number of interested parties, but one skeptical member asked that the specimen be given a hammer blow with the full pressure on. This was readily agreed to, and, since the workmen refused to strike the blow, the writer secured a 14-lb. hammer and struck twelve blows on the face of the flange, after which examination was made and no damage whatsoever was apparent. Six blows in the reverse direction were also given without producing any failure of the weld.

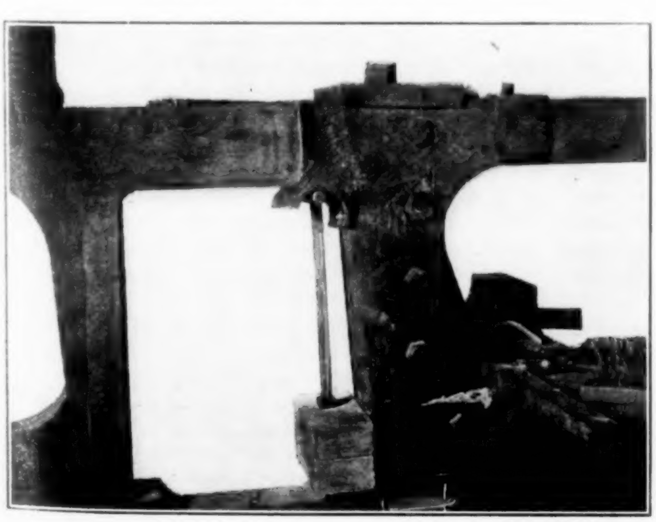

FIG. 6 ENGINE FRAME IN COURSE OF REPAIR BY WELDING

The weld was then tested. It was believed the weld was not more than 25 per cent efficient, for the operator had not given his best efforts to the work, and as the welding material was only of about 50,000 lb. tensile strength the effective area of welded material would probably show about 250,000 lb. This, however, was greater than the strength of the twelve 3/4-in. flange bolts, which was perhaps 150,000 lb. The weld was then pulled in an ordinary testing machine at 119,000 lb.

Although the test had proved the weld capable of sustaining a strain greater than ever likely to be met in service, it was completed by breaking the weld. To do this the flanges were enlarged, and when the piece was again pulled, the weld gave way at 208,000 lb., but before this the flange on each end had dished about 1/2 in.

The results of these tests, while showing that such a weld might be serviceable, nevertheless justify the statement that the weld was a failure, for the broken specimen showed that only about 1/5 of the welded material united with the pipe and flange. This was most apparent from the specimen itself, which thus justified the previous estimate, since 208,000 lb. is practically 20 per cent of the amount which it was assumed the weld would hold when figuring the 25 per cent weld at 250,000 lb.

In passing, it is of interest to note that in one of the large manufacturing plants near Philadelphia, Pa., there is a 2000-lb. hydraulic pipe system installed, every joint of which is arc-

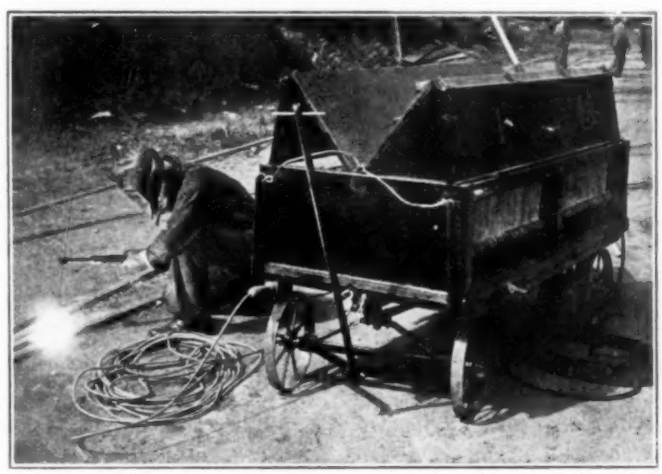

FIG. 7 550-VOLT RAILWAY ARC-WELDING SET

welded, and although it has been in service a year and a half no joint has developed a leak or given any trouble. There are a number of firms today who are using electric arc welding for securing flanges to pipes and making T and other connections on steam lines, and their excellent records testify to the ability of arc welding to withstand the many strains of time and service.

Many other examples could be presented. The following is one of particular interest, as it shows the service to be expected under severe conditions.

On the large 16-wheel articulated locomotive it is necessary to have a ball joint in the steam pipe between the two trucks, and one manufacturer has, for about six years, used the arc welding process to fasten in place the ball of this joint. This weld must stand vibration from the jar of the locomotive over track and joints, tension and compression from the forward and backward movement of the train, reverse strain as the curves from right to left are made, and an internal steam pressure of about 100 lb. Six years' service has brought no reports of failure.

As an illustration of the saving in time and money often resulting from arc welding, the following incidents are typical. The Italian ship *Titania* had a badly damaged rudder, but it was successfully repaired by arc welding at a saving of $10,000 and 4 months 2 weeks of time. One part of the weld was completely through the 6-in. by 9-in. rudder post. This vessel was repaired in August 1916 and has since seen constant service.

Another case of a broken rudder successfully repaired is

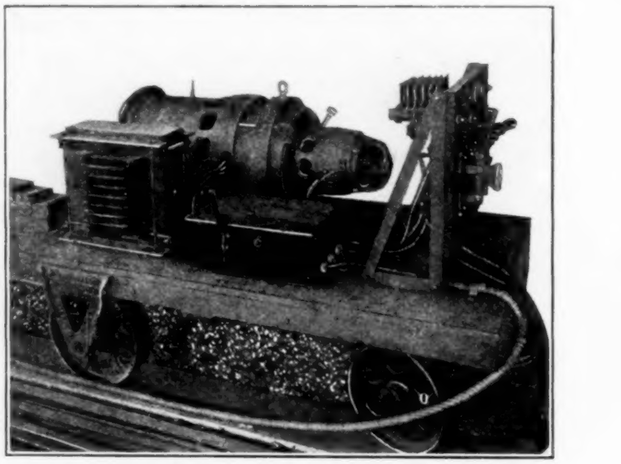

FIG. 8 PORTABLE MOTOR-GENERATOR ARC-WELDING SET

shown in Fig. 5. Here the rudder post was welded into place, the sketch clearly showing the operation. This work was done in May 1916, and if installed in the usual manner would have occasioned a delay of at least 6 months, with the necessity of using a dry dock. Instead, arc welding saved 10 per cent in cost and restored the vessel to service 5 months sooner.

An illustration of the use of arc welding in railroad practice is shown in Fig. 6. This is an engine frame broken at a place most inconvenient to weld. In this case, however, the repairs are being made with the frame still in place. Notice the V groove filled by arc welding, also the ingenious method used by the operator to obtain the desired fillet. He has used the half of an old brass lining to which the welding material will not readily adhere.

A report of the electrical engineer of one of the great middle-western railroad systems accredits to arc welding a saving of about $200,000 in one year. This saving was computed from economy in this method over others previously used on the same class of work, and also from the saving effected by the restoration to service of otherwise useless apparatus. Since that report this road has increased its number of welding units about 300 per cent.

Developments in welding equipment are shown in Figs. 7 and 8. Fig. 7 is a resistance grid for use on a 550-volt railway circuit, and it is a type in present-day service. For welding with a ¼-in. electrode it requires an approximate imput of 200 amperes at 550 volts or 110 kw. to produce 200 amperes at about 18 volts or 3.6 kw. at the weld, resulting in a total loss in wasted energy of 106.4 kw.

This type of apparatus is chiefly used for street-railway work, and the process has proved so successful that even the high cost of wasted electrical energy has failed to eliminate it as a most profitable and satisfactory investment.

A motor-generator of the type shown in Fig. 8 would accomplish the same result with an input of 6 kw., or 11 amperes at 550 volts. The weight of this unit and portable truck is about 1800 lb.

Among the great lessons which the recent war has taught us are economy and the conservation of our time, energy and raw material, and arc welding presents a veritable storehouse of opportunities ready for the engineer who will adapt them to his own requirements.

In the course of the discussion which followed Mr. Anderson's paper the following interesting facts were brought out. Since 1906, the Pelton Water Wheel Co. has used arc welding for very heavy work, in building up large steel castings. In making these castings the shrinkage stresses are so severe that the reinforcing ribs are often pulled apart and ruined. The reinforcing ribs are therefore cut to allow for this shrinkage and then welded.

In discussing the relative merits of alternating and direct current the consensus of opinion seemed to be that direct current is the more suitable for arc welding. Alternating current can of course be used, but it takes a more experienced man to maintain the arc, and in practice there are very few that are able to weld with any degree of satisfaction.

In discussing the question, What, in general, is the effect of the weld on the character of the metal? it was brought out that metallurgists and chemists are trying to arrive at some standard for electrodes. It must be remembered, however, that the parent metal has certain constituents that become molten. The electrode also becomes molten and it has certain constituents. These two commingle and form other elements which disappear in the heat of the arc, are carried off in the oxide, and sometimes, strange to say, form a new composition. The advocates of the covered electrodes claim one thing, others use fluxes, and still others metals in various proportions, and every one is claiming certain results for the particular method he uses.

Classical Education for Engineers

Dean Mortimer E. Cooley, in two articles published by the *Evening Sun* of New York, April 14 and 15, advocates the broadening of engineering courses by teaching young engineers three or four years of Latin and Greek, some political economy, considerable history, philosophy, a good knowledge of English and a speaking knowledge of at least one foreign language, preferably Spanish. He said that "the one great need today from our educational institutions is training for responsible citizenship" and rather than give our youth "a smattering of this and that so-called practical thing as a preparation for college" it were better to prepare them "to be of maximum use to themselves and their fellowmen."

The study of Latin and Greek, Dean Cooley remarked, sets forth before the mind the civilization and wars of early times and the characteristics of the people who developed that degree of culture which even in this time of tremendous achievements surprises us for its advancement.

He further emphasized the necessity for broadening the technical man by citing "the relation of the engineer, in the different branches of his science, to the worker . . . who typifies the constructive half of our civilization known as 'Labor,' and his equal and important intimacy with the other, the provisioning and directing half, usually termed 'Capital.'" Thus it is that the engineer being the connecting link between capital and labor, "there is one phase of the engineering profession . . . which is of even broader value to the nation than that of material advancement." And yet in spite of the "need of engineering skill in the direction of executive matters of state and national problems," engineers are unwilling to enter political life, precisely because "our technical institutions are specializing too much" and "vision, background, knowledge of life and the 'humanities' suffer at the expense of an almost selfish concentration on laboratory methods."

A new system is being set up in the world, continued Dean Cooley, and "our international leadership in industry, commerce and political idealism demands superior training for the young men who are to continue the administration of our affairs," because "no longer is government simply the administration of a system of statutes, the collection of taxes and duties and the maintenance of a military system," but "it is a complicated machine by which the citizens themselves drive forward the great industrial, social, commercial, aesthetic and idealistic entity of the State." And so it is that "our future engineers should stand head and shoulders above the present professional man of today to fulfill their full duties to the nation and to themselves as citizens."

Dean Cooley concluded with an exposition of the forces which inevitably led the German military machine to its complete destruction. The German war diplomacy "could not grasp the psychology and spirit of other peoples" and "the specialist . . . without his schedule, prepared and learned by rote, was nonplussed and conquered when his carefully built plan went wrong and found unexpected obstacles."

Relative Corrosion of Wrought-Iron and Steel Pipe

At the last Annual Meeting of this Society a paper was presented by Dr. William P. Gerhard of New York on the Relative Corrosion of Cast Iron, Wrought Iron and Steel Pipe in House Drainage Systems. The paper was based on the examination of the pipe-drainage systems in 78 tall buildings of New York City along the line of Broadway, beginning at Bowling Green and ending at Forty-second Street, a distance of approximately four miles. Numerous illustrations were given, taken from photographs of roof pipes which had corroded, in order to illustrate the effect of corrosion and to show its relative effect on different kinds of material.

There were also tables in which were tabulated in very complete form the data relative to the various installations and with respect to the observed conditions. Dr. Gerhard's conclusions with regard to welded steel pipe and welded genuine wrought iron pipe, a report upon which constituted the main part of his paper, were as follows:

Welded Steel Pipe. The investigation showed conclusively that *steel pipe* is *much inferior* to both *cast-iron* and *wrought-iron pipe* when exposed to corrosive action. In many cases the black steel vents showed sealing to a considerable depth after only ten years' use. Generally speaking, galvanizing was observed to be somewhat less of a protection against corrosion on steel pipes than on wrought-iron pipes. It appears that the galvanized coating does not adhere so firmly to the smooth surface of steel pipes as to the comparatively rougher surface of wrought-iron pipes. The galvanizing on steel pipes showed signs of disappearing within 10 to 20 years, after which time the life of such pipe may be assumed to be merely equal to that of ordinary black steel pipe.

Welded Genuine Wrought-Iron Pipe. The investigation has furnished an almost overwhelming evidence *in favor of genuine wrought-iron pipe* and *against steel.* To mention only one example, contrast the black wrought-iron vent pipes of the Mail and Express Building, installed 27 years ago, with the black steel vents in the Townsend Building, put in 22 years ago. It was also found that the galvanized coating lasts a little longer on the wrought-iron than on the steel pipes, but that ultimately the rust resistance of the base metal is of far greater importance than that of the coating.

Conclusions were also drawn with regard to the use and durability of cast-iron pipe having calked joints and screw-jointed pipe systems. Concerning these, it is stated that while it is freely admitted that cast-iron pipe, as such, is a satisfactory material for house-drainage purposes, and that many of the cast-iron roof vents inspected showed a much better condition as regards corrosion than anticipated, the objections to a cast-iron system, well-known heretofore and corroborated by this investigation, are the unsafety and unreliability of the calked joint. A calked joint can never be considered a permanent one as long as expansion and contraction cannot be eliminated.

An abstract of the paper was published in The Journal of the Society for November 1918, and the paper in complete form has been issued as a pamphlet.[1]

The discussion upon this paper was extended, and the account which follows is in abstracted form with duplicate matter omitted and the whole condensed in so far as possible without changing the intent of the writers.

Discussion

George Schuhmann. The discussion of the relative corrosion of wrought iron and steel started about twelve years ago, and to those who have kept informed on the subject the question has undoubtedly been decided in favor of wrought iron when used under ordinary working conditions. Unfortunately, the matter has been much befogged by the investigations of many experimenters who have based their conclusions on so-called accelerated corrosion tests such as acid tests, etc.

I made the same error a number of years ago after some steel pipe had been in use for a few years and the practical evidence pointed in the direction of a more rapid corrosion of steel pipe than of wrought-iron pipe. I found, by testing with diluted sulphuric acid, that while the steel pipe had been somewhat reduced in thickness, the immersed portion of the wrought-iron pipe had been completely ruined. Many other similar experiments were tried with practically the same results; but as the evidence of both wrought-iron and steel pipes that had been in use many years showed decidedly in the opposite direction, it led to further investigations in relation to the structure of the metal itself.

Chemical analysis did not lead to any practical results, as there is really not much difference between the chemical composition of wrought iron and low-carbon steel. There is, however, a decided difference in their physical structures, due to the great difference in their methods of manufacture.

The temperature in the puddling furnace in which pig iron is converted into wrought iron is about 2300 deg. fahr., not enough to melt wrought iron. After the pig iron is melted, the stirring up of the molten mass under the influence of the flame and the material composing the lining of the furnace causes the pure iron to separate from the impurities and solidify because the temperature of the furnace is not high enough to keep the purified iron liquid. The carbon in the pig iron is burned out and the other impurities form a liquid cinder in which the pure-iron globules float around like sugar crystals in molasses in a vacuum pan. When this spongy mass is removed from the furnace and compressed by squeezing, hammering and rolling, much of this fluid cinder is expelled, but a thin coating of each globule remains, and when the mass is rolled out the iron fibers become coated with minute capsules of cinder. This cinder consists principally of silicate of iron, and because silicate of iron resists ordinary corrosion much better than pure iron, the presence of the silicate in wrought iron causes it to resist corrosion better than steel.

Steel, on the other hand, is made at a much higher temperature, which keeps the whole mass liquid, and the cinder generally floats to the top, where it is removed. After the steel melter has finished his work the metal is still in a liquid state—too hot for rolling—and it must be allowed to cool, during which process soft impurities which remain flock together in a liquid mass by what is technically known as "segregation."

While silicate of iron resists corrosion due to ordinary exposure much better than pure iron, it readily dissolves in a strong acid, which explains the results obtained by means of the accelerated corrosion tests. Further evidence that cinder or slag with which wrought iron is impregnated affords resistance against slow corrosion has been demonstrated by observations upon the durability of sheet-iron roofing reported by Mr. R. C. McBride, of Youngstown, Ohio.[1]

Another important factor to which I will call attention is that corrosion acts very capriciously, sometimes concentrating itself on certain spots (pitting), while at other times and under apparently the same conditions it will diffuse itself over larger areas. Several years ago, in the Indiana gas belt, two parallel pipe lines were taken up on account of the gas giving out. Each line was 25 miles long, and the two lines had been laid side by side in practically the same soil and had transported the same kind of gas. The wrought-iron pipe was 8 in. in diameter and had been in service 18 years, while the steel pipe was 6 in. in diameter and had been in service only 11 years. While $24\frac{3}{4}$ miles (over 99 per cent) of the wrought-iron pipe was still in good condition after being taken up, 1200 ft. (nearly 1 per cent) was corroded so as to make it unfit for further use. On the other hand, 14 miles (56 per cent) of the steel pipe was thrown aside for the above reason, 11 miles, or 44 per cent, being still in good condition.

Wm. W. Walker[2] expressed the opinion that the author's investigation was too fragmentary to warrant his broad generaliza-

[1] The Relative Corrosion of Cast-Iron, Wrought-Iron and Steel Pipe in House-Drainage Systems, Wm. Paul Gerhard. Price, 15 cents to members, 30 cents to non-members.

[1] Corrosion Tests, *Engineering Record*, May 20, 1911.

[2] Professor of Chemical Engineering, Mass. Inst. of Technology, Cambridge, Mass.

tion as to the superiority of genuine wrought-iron pipe over steel pipe. He further said:

In Par. 48 the author speaks of his investigation as having afforded . . . "an excellent comparison of the life of wrought-iron and steel pipe under equal conditions to service." . . . Inasmuch as in no single case were samples of wrought iron and steel taken from the same continuous structure, I can state from my experience that the conditions of comparison were very inadequate and the results can be entirely misleading. The factors which control speed of corrosion are so many and so difficult of determination that unless two pieces of metal have been subjected to *identically the same conditions* a comparison as to durability is worthless.

The broad statement that genuine wrought-iron pipe "has shown itself in actual service and under a variety of conditions. . . . to be much more resistant to corrosion than steel pipe," I must most emphatically deny. I can state with conviction that whether the wrought iron outlasts the steel, or the steel outlasts the wrought iron, depends upon whether one is dealing with good steel and poor wrought iron, or good wrought iron and poor steel.

John L. Robbins[1]. The author's conclusion that genuine wrought-iron pipe is far more durable than steel pipe for house drainage purposes does not seem to me to be proved at all. Most of the tests, the results of which showed the wrought-iron pipe to be in better condition than the steel, were made on piping which was installed when wrought-iron pipe was at its best and steel pipe was at its worst. The author's conclusions are based on the inference that the pipe of today is of the same standard as that used in most of his tests, and make no reference to the great improvement in the steel pipe of recent years. In buildings erected eight or nine years ago, such as the Fifth Avenue Building and the Martine, the steel pipe in the author's tables shows up as "as apparently good," or as "good as new."

A. F. Hansen[2] devoted considerable attention to a discussion of the merits of the screw-pipe system of wrought iron or steel pipe, and of the use of cast-iron pipe with lead-calked joints for drainage and vent pipes.

Much controversy has existed among engineers about the relative value of cast iron compared to wrought iron or steel pipe in house-drainage systems, but it has been heretofore generally conceded, and Dr. Gerhard also concludes that the life of extra heavy cast-iron soil pipe is fully as great as that of genuine wrought-iron pipe. Mr. Hansen's own observation was that the life of cast-iron pipe for drainage systems has been proved for about 60 to 70 years, whereas proof exists that wrought iron has outlived a period of but 30 to 35 years in drainage systems. The criticisms against the use of cast-iron pipe consist of the alleged weakness of lead-calked joints; the possible existence of sand or blow holes; and the greater number of joints required.

He said that while the weakness of the calked joints as pointed out by the author is true to some extent, the very fact of possible expansion and contraction of cast-iron soil-pipe systems at their leaded joints is a distinct advantage, especially in tall buildings.

One of the chief objections to the use of screw pipes is the combination of screw pipe with galvanized cast-iron fittings. The galvanizing hides serious defects and the fittings are easily cracked by the expansion and contraction of the rigidly connected screw pipes. He considered other objections to be a reduction of the thickness of the metal at the threaded ends; the peeling off of the galvanizing at the ends where the threads are cut; the difficulty of making repairs; the use of steel-pipe nipples which, if it is admitted that steel pipe itself is unsatisfactory, are still less desirable because of the cutting away of the metal in threading; and obstruction to flow in the pipes due to neglect on the part of the workman in reaming the ends or in allowing red lead to enter the pipe when making the joints, where it hardens.

As to the question of the higher cost of completed wrought-iron drainage systems over completed extra heavy cast-iron soil pipe, the author secured comparative estimates of cost of a genuine wrought-iron galvanized Byers pipe stack, 100 ft. long, with a galvanized cast-iron drainage branch fitting every 10 ft., and a similar extra heavy cast-iron soil-pipe stack. The quotations furnished cover stacks, 2 in., 3 in., 4 in., 5 in. and 6 in. in diameter. The excess cost of galvanized wrought-iron stacks is as follows:

Stack diam., in.	2	3	4	5	6
Excess cost, per cent:					
W. G. Cornell & Co.	0	25	55	70	85
Lasette & Murphy	23	65	74	97	119

Referring specifically to the question of corrosion in the discussion in the author's paper, Mr. Hansen said:

"I believe that the opinion of engineers who are competent to judge, favors the use of wrought iron for plumbing water-supply pipes even though its cost is somewhat in excess of steel pipe."

Engineers, architects and contractors have frequently questioned the wisdom of using genuine wrought-iron pipe because of this additional expense. No specific proof had been brought which would warrant them in spending their clients' money in this manner. It is of the greatest interest, therefore, to find that Dr. Gerhard draws the conclusion from his investigations covering an inspection of the pipe drainage systems in 78 tall buildings, that genuine wrought-iron pipe is far more durable for house-drainage purposes than a steel pipe. A careful study of his detailed report indicates that this conclusion is correct.

It should be understood, however, that the author's investigation did not cover main and branch vent pipes in the building, which, of course, are difficult of access. Roof vents are exposed to the corrosive action of both the atmosphere and rain water, and the oxidizing agents which they contain, as well as to the corrosive influences of the sewer air.

W. H. Kenerson.[1] The paper is interesting because of the very definite conclusion reached as a result of the author's investigations. For a great many years I have followed the discussion of this subject with much interest and have made many investigations myself but without being able to arrive at any such positive conclusion as the author. Prior to ten or fifteen years ago, before steel pipe was made as well as it is today, it was rather easy to find many examples where wrought iron was distinctly superior to steel, but of late years this condition has changed. Evidence collected at random is so very contradictory that it would not be at all difficult, by properly choosing data, to "prove" that either wrought iron is superior to steel or that steel is superior to wrought iron, whichever seems desirable for the moment.

Sometime ago I was asked by the National Tube Company to secure various kinds of iron and steel pipe and determine their relative corrosion in a hot-water line in one of the dormitories at the University. I installed two series of pipes of identical size and length, including genuine wrought iron, black "wrought," black copper alloy, galvanized "wrought," and galvanized copper alloy. After about a year of use all of the pieces were in such poor condition that they were practically useless. No very great difference existed between them. The tests indicated the slight superiority of the black "wrought" or steel pipe over the others, but it might not be unlikely that another similar series of tests would reverse the conclusion.

For many years I investigated personally, or caused to be investigated, the relative corrosion of pipe lines of various kinds, and it is my experience that with modern steel pipe and well-made wrought-iron pipe there is very little if any difference in behavior under corrosive influence. One of the most convincing evidences to me is the fact that while practically all pipe lines, both steel and iron, include wrought-iron couplings, I never have seen myself nor has anybody reported to me any difference in the condition of the couplings and pipe in any given line. I have found many individual cases where wrought iron appeared superior to steel, and many cases where the reverse is true. I am inclined to believe that Mr. Gerhard's positive "proof" of superiority of wrought iron over steel may hold for the cases he instances, but is not completely convincing as a general proof.

[1] Robbins, Gamwell & Co., Pittsfield, Mass.
[2] Hydraulic and Sanitary Engineer, 2 Rector St., New York.

[1] Professor of Mechanical Engineering, Brown University, Providence, R. I.

J. O. Handy.[1] The author's investigation, to have been conclusive, should have included every precaution to avoid errors in distinguishing wrought iron from steel. A qualitative test for manganese, such as was used, is not sufficient to distinguish between wrought iron and steel, particularly when the amount of metal used varies to an unknown degree. The manganese content of wrought iron is known to be very variable, and that in steel of the kind used for pipe is by no means constant.

In our own practice, we do not consider that we have proved pipe to be steel or iron until we have determined carbon, manganese and silicon *quantitatively*, and also made a microscopic examination.

A second source of error was not taken into account by the author, viz., that small percentages of copper, such as are sometimes found in wrought iron, cause it to be very resistant to corrosion by atmospheric influences. Extended tests have shown that wrought iron free from copper is no more durable than steel. On the other hand, when both the wrought iron and steel contain the same amount of copper, they are equally durable.

I have personally taken part in a number of very thorough tests of wrought-iron and steel pipe under the most severe service conditions in hot-water systems. For the purpose of securing results in a shorter time, ungalvanized wrought-iron pipes were purchased in the open market, cut to the same lengths, and exposed in the same hot-water line with steel pipes. After 14 months the line was taken down and it was found that the pitting of the wrought-iron pipe and of the steel pipe had been equally deep and extensive. The amount of roll scale adhering to the pipe was the controlling factor in determining the degree of pitting. Steel pipe free from scale did not pit, and the corrosion in general was much less. A detailed report of Part 1 of the corrosion test of steel pipe to which I have just alluded may be found in the Journal of the American Society of Heating and Ventilating Engineers, page 159, volume for 1917. The tests showed that genuine wrought-iron pipe of the two best-known brands was no more durable than steel pipe having the usual roll-scale covering. On the other hand, steel pipe freed from scale by a special process of rolling was far more durable than either of the kinds of pipe just mentioned.

Bearing on the relative durability of steel and iron containing small percentages of copper are the following references:

D. M. Buck: Keystone Copper Bearing Steel. A Discussion on Corrosion, July 1914. (Jl. Am. Iron & Steel Inst., May, 1915.)
D. M. Buck and J. O. Handy: Research on the Corrosion Resistance of Copper Steel. (Jl. Ind. & Eng. Chem., 1916, p. 200.)

The author's conclusions, which are based on insufficient evidence as to the composition of drainage pipe which failed, are not convincing to one who has taken part in scientifically conducted researches in the corrosion field. His observations upon vent pipe also are not dependable, because the identity and composition of the pipes were not established beyond question.

[Mr. Handy transmitted with his discussion a copy of a report upon tests made by the Pittsburgh Testing Laboratory to determine the comparative resistance to corrosion of wrought-iron and steel pipe when used in a system supplying hot water to shower baths. The tests were made upon ungalvanized pipe in a hot-water system during a period of 14 months. No significant differences were discovered in the depth or extent of the pitting as between the steel or wrought-iron pipe. Both had corroded rapidly. The main factor in its influence upon corrosion appeared to be the roll scale. Where this was removed by mechanical processes the rate of corrosion was diminished to about 20 per cent of the rate for pipes carrying the usual covering of roll scale. Inasmuch as Dr. Gerhard specifically states in his paper that his "investigation was restricted to the drainage and vent system, and the hot- and cold-water pipes were excluded from consideration," the report will not be given here in detail.—Editor.]

F. N. Speller.[2] The author's statement that "Steel pipe is vastly inferior to genuine wrought iron pipe" is based, as he says, on inspection of roof vents, the relative condition of the drains (the important part) being mainly based on the assumption:

1. That all vents examined were subject to the same kind of service.
2. That his observations of corrosion in vents were representative of wrought iron and steel as a class and that the same conditions of corrosion prevailed in the drains as in the vents.
3. That material in the drain pipe which failed is the same as the vents or other pipes in the system.

No evidence is given to warrant the first of these assumptions, but granting this for the present, the investigation on the vents is interesting only as a comparison of metals under atmospheric corrosion—the air evidently being the most important factor, as the corrosion of these vents is always more pronounced near the top.

The results would be more valuable if the method of identification had been more conclusive and had the copper and other elements been determined. Those who have gone into this subject are now almost unanimously agreed that in atmospheric corrosion certain elements, particularly copper, have a controlling influence regardless of whether iron is made in a puddling furnace or in the bessemer converter. Some steels are so low in manganese as to pass as wrought iron under the rough qualitative test used in this investigation unless fracture or etching tests are also applied. Several references are given below, containing general information on the influence of copper in iron under atmospheric corrosion.[1]

It has been proved by tests in service to destruction that 0.1 per cent to 0.3 per cent copper (or even less) has a very marked effect in prolonging the life of iron in air, so much so that bessemer copper steel has been found to be practically as good as new after reworked wrought iron and ordinary steel had been entirely destroyed.[2]

"As further evidence of the influence of copper content, we have lately taken down some tests which were started seven years ago with a view to determining the effect of small additions of copper to pipe steel exposed to impure air. The results are shown in Fig. 1. After some consideration it seems that this should offer a solution and a remedy for the trouble experienced with vent lines and drains, although it should be understood that it is not suggested as a remedy for corrosion in water pipes and under other conditions as the copper does not seem to have much influence except under gaseous corrosion. We have found that iron pipe is protected by a small percentage of copper steel, so that it is quite probable that if Dr. Gerhard had made a complete analysis of the iron pipe and determined the copper he would have found a relation between the copper content and the corrosion.

"The sulphur and silicon contents should also be considered, so that one should be careful in concluding from the data presented in the paper that vent lines of wrought iron are necessarily superior to steel. Moreover, the size and thickness of these vents are not given nor how each one is used. Condensation in the upper portion above the roof is obviously responsible for the greater corrosion of these vents near the top and this would depend largely on what kind of fixture the vent is attached to. Also, no information is given as to the relative corrosion inside and outside nor how often these vents were painted."

"As direct evidence on genuine wrought iron and steel under severe atmospheric corrosion, the following is submitted:

"Portions of a pipe fence on a river wall at McKeesport, Pa., were constructed alternately of 2-in. black wrought-iron (puddled without steel scrap) and bessemer-steel pipe. This was erected October, 1906, and removed August, 1917, after nearly eleven years. The arrangement of test, condition of the wrought iron and steel and analyses of pipe are shown in Fig. 2 and in Table 1 which follow. The depth of pitting and general condition

[1] Director of Department of Chemistry, Metallurgy and Mining, Pittsburgh Testing Laboratory, Pittsburgh, Pa.
[2] Metallurgical Engineer, National Tube Co., Pittsburgh, Pa.

[1] Burgess and Aston: Influence of Various Elements on the Corrodibility of Iron and Steel, Journal of Industrial and Engineering Chemistry, June, 1913.
D. M. Buck and J. O. Handy: Research on Resistance to Corrosion of Copper Steels, Journal of Industrial and Engineering Chemistry, 1916.
O. W. Storey: Corrosion of Fence Wire, Transactions of American Electrochemical Society, 1917.
Report of Committee A-5: American Society for Testing Materials, 1918 Proceedings.

[2] Figs. 4 and 5, paper by D. M. Buck, "Recent Progress in Corrosion Resistance," American Iron and Steel Institute, May, 1915.

was practically the same on both materials when the fence was removed. Some pieces of each material had corroded through at the posts. It will be noticed that the worst corrosion on the steel is in the bottom row, as would be expected. The bottom row of wrought iron, however, does not show this increase, probably due to the copper contents. This fence was given one coat of black paint after erection, with no further attention."

In the course of his discussion Mr. Speller called attention to a number of the author's comments which he contended were inconclusive or misleading. One of these, typical of three or four others, states that two main drainage lines in the Home Life

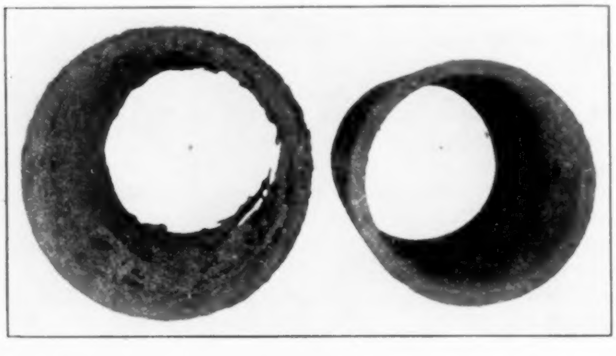

FIG. 1 CORROSION OF STEEL PIPE EXPOSED TO MOIST MILL ATMOSPHERE FOR SEVEN YEARS. FIRST VIEW, PIPE WITHOUT COPPER CONTENT; SECOND VIEW, PIPE WITH COPPER CONTENT

Building failed after 25 years and that "*these were probably steel because other lines in the cellar were tested and found to be steel.*" He considered such evidence to be inconclusive, particularly in view of the fact that nearly all piping in buildings constructed during the past 30 years has consisted of mixed steel and wrought-iron construction, as confirmed by the author's investigations. Another objection, he said, is that "*relative* corrosion varies with conditions especially as between gases and liquids, so that any conclusion as to corrosion in the drains should be based on a direct examination of these drain pipes and not by assumption and inference from material exposed mainly to atmospheric corrosion.

"However, taking all the results of examination of drainage pipes, as reported in Table 1, as the basis of comparison, but eliminating such cases as No. 58 where the house drains are reported as 'Wrought iron; could not inspect; no trouble,' as incompetent and immaterial, and including in the first place only those buildings where the author was able to examine the pipe which had failed or where there had been no trouble, and it had been possible to make tests on the drains, we find from the author's notes, Table 1:

Pipe material and service given, as reported in Table 1.	Investigation in which replaced pipe was examined and tested or where no trouble had been experienced with drains, the kind of pipe determined from tests on drains.		Including additional cases where the kind of pipe is inferred from examination of other pipe in building.	
Wrought iron, good	11, 12, 17, 67,	4	22, 43, 52, 65,	8
Steel, good	16, 19, 20, 28, 71, 73,	6	50,	7
Wrought iron and steel, good	5, 6, 7, 9, 42,	5	38,	6
Wrought iron, failed	63,	1	64, 77,	3
Steel failed	46,	1	31, 40,	3
Wrought iron and steel, failed	2, 37,	2		2
	Total	19	Final total	29

Note.—Nos. 58 and 61, in which report apparently favors wrought iron, and 62 and 70, apparently favoring steel, were left out for lack of any evidence as to material involved.

TABLE 1—HARBOR WALL RAILING

Section Used for Experimental Purposes—Post, 4½-in. Pipe; Railing, 2 in. Pipe. Erected October, 1906. Removed August 9, 1917.

STEEL PIPE

	Serial No.	S	P	Mn	C	Average depth of pits, in.	Deepest pit, in.
Top Row	1	.073	.111	.46	.08	.030	.055
	2	.085	.104	.32	.08	.031	.065
	4	.052	.136	.34	.07	.028	.043
	5	.042	.140	.38	.06	.027	.035
	6	.067	.114	.47	.07	.056	.073
	7	.039	.124	.34	.07	.029	.038
Middle Row	8	.090	.113	.39	.07	.019	.025
	9	.066	.100	.43	.08	.031	.038
	10	.070	.113	.44	.08	.037	.045
	11	.065	.103	.38	.07	.054	.063
Bottom Row	15	.054	.107	.35	.07	.033	.040
	16	.067	.105	.40	.07	.060	.071
	17	.062	.108	.37	.07	.061	.073
	18	.088	.106	.35	.07	.064	.073

IRON PIPE[4]

	Serial No.	S	P	Mn	O	Average depth of pits, in.	Deepest pit, in.
Top Row	3	.024	.129	.11	2.20	.032	.045
Middle Row	12	.022	.137	.12	1.78	.043	.053
	13	.022	.139	.11	1.97	.030	.035
	14	.022	.131	.11	2.00	.038	.047
Bottom Row (Copper steel)	19[1]	.032	.110	.09	2.60	.041	.050
	20[2]	.026	.130	.09	2.07	.046	.054
	21[3]	.028	.105	.11	2.33	.053	.062

[1] Copper, 0.10 per cent. [2] Copper, 0.06 per cent. [3] Copper, 0.08 per cent.
[4] Analyses of iron pipe below all showed a trace of carbon.

"Of course it would have been more desirable had there been more evidence of this kind and especially from more pipe from the drains of the same buildings. However, the data given certainly do not support the author's conclusion as to the inferiority of steel pipe for drains, but on the contrary indicate surprisingly little trouble, and what there is, according to the data, is at least equally divided between wrought iron and steel.

"Most of the steel pipe included in this report was made over 10 years ago before 'Full weight' became standard, and before improvements in the manufacture of modern steel pipe had been developed and put into practice. Much of the drain and vent pipe in use at that time was light merchant weight with no protective coating."

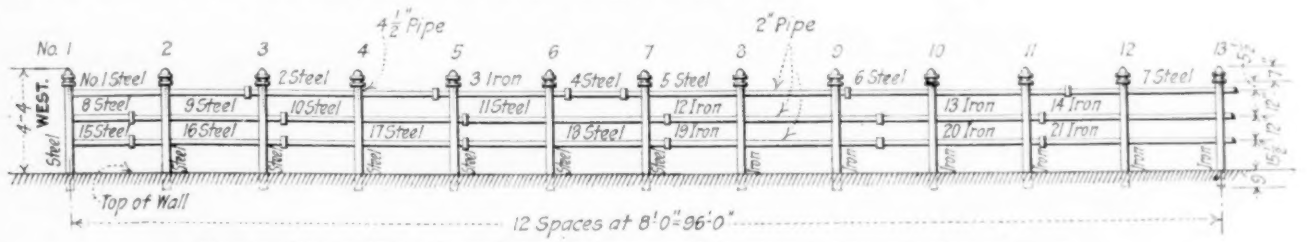

FIG. 2 HARBOR WALL PIPE FENCE SUBJECTED TO CORROSIVE ACTION FOR ELEVEN YEARS

JAMES ASTON, in comment on the four references given by Mr. Speller, and as joint author of one of them (Burgess and Aston), sent the following analysis of these investigations:

The work of Burgess and Aston covered tests upon small samples only, and was not a test to destruction but solely upon the weight lost in a one-year interval. Again, it did not refer to comparative tests of steel and wrought iron but dealt entirely with the influence of different alloying ingredients upon the corrosion loss in the atmosphere; among these was copper-bearing material. Wrought iron played no part in the test or in the discussion of results.

The paper of Storey covered an examination of old barbed-wire fence, and he noted that where the steel wire was in good condition it carried copper, whereas wires which had been destroyed were free from copper. While practically all of the samples were steel, it is significant that there were a few wrought-iron samples; these were in as good condition as the copper-bearing steel and they contained no copper.

The tests of the American Society for Testing Materials deal with sheets exposed to the weather. Among these are all classes of steel and some wrought iron sheets with and without copper. While some of the steel sheets, especially bessemer steel, have failed, the tests have not progressed far enough to be conclusive,

particularly with regard to the relative durability of wrought iron and copper-bearing steel.

The paper of Buck and Handy cites only steel and ingot iron products, the tests including full-size sheets exposed to the weather, and accompanying exposure of small samples 2 in. by 4 in. in size for record of loss of weight. No mention is made of wrought iron.

Author's Closure

Mr. Hansen refers in his discussion to the question of the relative merits of steel and genuine wrought iron pipes for water supply lines. As this is a subject by itself, which was not involved in the author's investigation, no reference need be made here. But further on Mr. Hansen agrees with the author "beyond the shadow of a doubt" that for house drainage purposes genuine wrought-iron pipes are far more durable than steel pipes.

The question raised, as to whether atmosphere and rainwater or the sewer air produced the larger percentage of corrosion, appears to the author to be one of small significance in view of the fact that *all* vent pipes examined and tested were subject to identical conditions of service, regardless of whether they were of steel, wrought iron, or cast iron.

As regards cast iron pipe, Mr. Hansen concedes the weakness of the calked joint, which was the principal point brought up by the author against the use of cast iron in house drainage.

As to the higher cost of screw-jointed pipe systems, this is, to some extent, conceded, especially for small installations. In large installations, however (both in tall buildings and in extensive groups of low buildings), contracting firms equipped with the required pipe-cutting machinery have frequently made but a slight difference, and sometimes none at all, between the cost of a cast-iron calked and a welded screw-joint pipe system. I prefer disregarding the comparative estimates of cost submitted by Mr. Hansen, which I understand to be recent figures, and not figures based upon "pre-war" conditions. Prices of material and cost of labor or both, at the present time are factors of considerable uncertainty, and no definite or important conclusions should be based on them.

Mr. Schuhmann maintains that the question of relative corrosion of wrought iron and steel pipe has "undoubtedly been decided in favor of wrought iron pipe, when used under ordinary working conditions." The author's investigation was based solely upon roof vents in use under ordinary or normal conditions, and no accelerated corrosion tests were considered.

In preparing his paper, the author was not unaware of the fact given by Mr. Schuhmann that some of the discussions before the American Society for Testing Materials, and many experiments made by individuals, confirm the superiority of wrought-iron pipe.

In reply to Professor Walker's statements, it is to be regretted that he could not bring himself to look upon the author's investigation as more than a "fragmentary" investigation and "a statement based upon inadequate data." Professor Walker indicates his belief that there is practically no difference in the corrosion of steel and wrought iron; the author is convinced, nevertheless, that if he had had Professor Walker's assistance or company in his examination of these numerous New York roof vents, he could hardly have escaped changing his opinion.

It would be useless to try to refute Professor Walker's assertion that the data gathered were "inadequate."

Professor Walker is obviously in error when he says that "in no single case were samples of wrought iron and steel taken from the same continuous structure (!)" What fairer proceeding could there be than to take samples and record conditions of corrosion from both wrought-iron and steel pipe standing alongside of each other, *on the same roof, under equal conditions, serving the same class of fixtures, and of equal length of service,* as was done at every opportunity?

In view of this, Professor Walker's contention that the conditions of service were not identical and therefore that no comparisons as to durability can be made is quite incomprehensible.

From his knowledge of the manufacture of wrought iron pipe, the author contends that Mr. Robbins is mistaken when he asserts that wrought-iron pipe made twenty or thirty years ago was a better article than it is to-day, nor does the author believe that there has been in recent years such "a great improvement in the manufacture of steel pipe" as he claims. Five years of service is apparently not a sufficient exposure to corrosive conditions for vent pipes, and for this reason, neither wrought-iron nor steel pipe of such limited age of service was taken into consideration in this investigation.

Professor Kenerson intimates that some of the data on roof vents may have been "properly chosen" to prove that wrought iron is superior to steel. The facts, however, are these: The investigation was begun at the lower end of Broadway and extended to 42d Street, taking in the buildings on both sides of the street in consecutive order, omitting only those which were of very recent date, and buildings of minor importance. In not one case, on entering the buildings and proceeding to make the examination, did the investigators know what kind of pipes they would encounter on the roofs, or in the cellars. The author neither collected his evidence "at random" nor did he aim to chose only data to prove wrought iron superior to steel.

Mr. Handy claims that the qualitative manganese test is not sufficient to distinguish between wrought iron and steel. It is distinctly stated in the paper that fracture tests were made in a number of cases; and where any doubt existed, larger samples of the pipes were submitted for further physical test and qualitative analysis to the metallurgical and chemical departments of Columbia University.

But it must be obvious that where so many hundreds of pipes were under investigation, it would have been both too expensive and too slow a process to have a complete quantitative analysis made of every single pipe. Mr. Handy is, to my knowledge, the only person broadly claiming that the so-called "manganese test" is insufficient and unreliable.

As to the claim that the "copper content" of wrought iron causes this to be very resistant to corrosion, I will refer to the tests of a harbor wall railing, introduced in the discussion by Mr. Speller. The deepest pits, according to these tests, were found in wrought iron pipe, having respectively 0.10%, 0.06% and 0.08% of copper, and where the wrought iron pipe contained no copper the deepest pits were less in extent according to this very table. The further contention that "where wrought iron and steel contain the same amount of copper they are equally durable" is in exact contradiction of what Mr. Speller shows in his table, as evidence that steel pipe without copper content is more durable than wrought-iron pipe with copper.

In Mr. Speller's discussion there are certain inconsistencies and inaccuracies to which attention should be called.

The main purpose of the writer's investigation was to find if commercial wrought-iron pipe purchased in the open market and installed in house drainage systems is superior in rust resistance to steel pipe obtained and used in the same way. Neither steel nor wrought iron pipe has ever been marketed according to their copper content, hence this and other questions as to complete analysis, brought up by Mr. Speller, are not of interest. Moreover, a careful perusal of reports and other literature on *pipe corrosion* fails to reveal the slightest mention of copper content in pipe. Assuming, however, that copper does retard corrosion, about which point metallurgists do not seem to be agreed, it seems absurd to the author to assume that all the iron pipes of this investigation contained copper, and that all the steel pipes were free from it.

Mr. Speller's arguments as to copper content in the wrought-iron pipes having a marked effect in the prolonging of the life of iron in air, are inconsistent and unconvincing, for the very table which he introduces to prove that copper content reduces liability to corrosion shows that wrought-iron pipes with copper content showed a deeper average pitting (0.053) or corrosion than those which did not contain copper (0.045). If this is quoted to prove anything at all, the author's interpretation would be that *copper-bearing wrought iron* is *inferior* to wrought iron without it.

Furthermore, it seems ridiculous to assume, as Mr. Speller apparently does, that among the hundreds of vent pipes tested, all of these of steel should happen to have been installed so as to be subject to severe corrosive conditions, whereas all the wrought

iron ones, in many cases interspersed at random, should have been so placed as to be shielded from corrosive attack.

The fact is, these hundreds of pipes inspected were all installed, practically in the same manner, in the same kind of service, in the same locality, hence the operation of the *law of averages* applies, and minor differences as to composition, original thickness, service conditions, etc., can be disregarded. It is not an *assumption,* as claimed by Mr. Speller, but a *fact* that all the roof vents examined and tested were subject to the same kind of service, for such *roof extensions of soil, waste as well as vent lines are always intended for the removal of sewer gases from the house drainage systems, and all of them without exception are subject to the corrosive action of not only sewer air, but also of the outdoor atmosphere and at times of rain water.*

Mr. Speller expresses a doubt as to the validity of the methods of identification of the pipes, contending that some steel pipe has such a low manganese content as to pass as wrought iron, whereas the author distinctly stated that in many cases the chemical tests were supplemented by fracture tests, also that in *doubtful* cases larger pipe samples were referred to the metallurgical and chemical departments of Columbia University for chemical and microscopical determination.

Mr. Speller further contends that the author's conclusions as to the drains were based on the condition of the roof vents, whereas the author distinctly stated that "the information as to corrosion of drains *is not supported by direct evidence* as in the case of the roof vents," because it was found impossible except in the few isolated cases mentioned to obtain samples of drain pipes which had been removed on account of having corroded through. Yet the fact remains that in those cases of drain failures, where information could be obtained, the evidence, even though circumstantial, pointed to the fact that the corroded pipes were of steel.

The author agrees with Mr. Speller that it would have been desirable if more evidence had been obtained from the drains of such buildings, but he found this either impossible or impracticable. It is to be hoped that when Mr. Speller continues his research on drain pipe he may have better luck.

In making a plea for the better quality of steel pipe made in recent years, Mr. Speller states that formerly the steel pipe manufacturers were in the habit of delivering light, i.e., short-weight pipe, but is not this likewise true of some of the wrought-iron pipe formerly made? And if true, wherein lies the difference?

In spite of Mr. Speller's conclusion that the condition of the steel pipes indicated "surprisingly little trouble," the author believes that one cannot carefully examine the photographs accompanying his paper without becoming strongly impressed with the great difference in the corrosion of wrought-iron and steel pipe, and without noting the fact so clearly brought out, of the *vastly better average condition* of the wrought iron pipes as compared with that of the steel pipes.

Airship Development

In 1910, the average endurance of the German rigid airship at a cruising speed was under one day, and the maximum speed about 50 miles an hour. In 1918, with the German L70 class of 2,195,000 cu. ft. capacity, the endurance at 45 miles an hour rose to 177.5 hours, and the speed to 77 miles per hour. The British R38 class, a contemporary of the German L70, has a capacity of 2,720,000 cu. ft., and an estimated cruising endurance, at 45 miles per hour, of 211 hours. In a note on the possibilities of the commercial airships, issued recently by the British Air Ministry, it is predicted that future airships will have a capacity of 10,000,000 cu. ft., a propelling apparatus of 6000 hp., and a maximum speed of 85 miles per hour. These ships would be 1000 ft. in length, 150 ft. in overall height, possess a range of 20,000 miles, and could stay aloft for three weeks without requiring refilling. The crew would consist of three officers and 26 men, and the freight capacity would be 200 tons. The cost of a 10,000,000-cu. ft. airship is estimated at between $1,000,000 and $1,500,000. From *Aviation,* February 1, 1919.

WORK OF THE BOILER CODE COMMITTEE

The Boiler Code Committee meets monthly for the purpose of considering communications relative to the Boiler Code. Any one desiring information as to the application of the Code is requested to communicate with the Secretary of the Committee, Mr. C. W. Obert, 29 West 39th St., New York City.

The procedure of the Committee in handling the cases is as follows: All inquiries must be in written form before they are accepted for consideration. Copies are sent by the Secretary of the Committee to all of the members of the Committee. The interpretation in the form of a reply is then prepared by the Committee and passed upon at a regular meeting of the Committee. This interpretation is later submitted to the Council of the Society for approval, after which it is issued to the inquirer and simultaneously published in MECHANICAL ENGINEERING, The Journal of the Society, in order that any one interested may readily secure the latest information concerning the interpretation.

Below are given the interpretations of the Committee in Cases Nos. 215-227, inclusive, as formulated at the meeting of April 1, 1919, and approved by the Council. In this report, as previously, the names of inquirers have been omitted.

CASE No. 215

Inquiry: Is it permissible under the requirements of Par. 257 of the Boiler Code to remove the caulking edges of plates, butt straps and heads by burning them off by the oxy-acetylene process instead of planing, milling or chipping,

Reply: Removing the calking edges of plates, butt straps and heads by the oxy-acetylene burning process will not be in compliance with the intent of the Boiler Code in Par. 257.

CASE No. 216

Inquiry: An interpretation is requested of the relation between Section *A* of Par. 275 of the Boiler Code and Sections *B* and *C*. Section *A* would appear to allow 12 per cent additional relieving capacity to a valve than either Section *B* and *C*.

Reply: The Committee purposely limited the requirements for rating of safety valves to 3 per cent increase over that at which the valve is set to blow, that is, one-half the maximum allowable increase in pressure of 6 per cent, so that a margin of safety represented by the difference between 6 per cent and 3 per cent would be provided.

CASE No. 217
(Annulled)

CASE No. 218

Inquiry: For material to be used as headers and manifolds of superheaters, does that of the open-hearth, extra-heavy, lap-welded steel pipe meet the requirements of Par. 11 and the material specifications of the Boiler Code? It is found that the average analyses of such lap-welded pipe appear to meet the physical and chemical requirements of either the boiler plate steel specifications, or the specifications for steel castings of Class B Grade, although they do not conform fully to either one separately.

Reply: It is the opinion of the Committee that, under the requirements of Pars. 9 and 11, headers and manifolds of superheaters must be constructed from material which in its initial form of plate or skelp, conforms to one or the other of the specifications given in the Boiler Code for wrought steel, or they may be constructed of cast steel of the Class B Grade. See reply in Case No. 208.

CASE No. 219

Inquiry: *a* Is the intention under Par. 184*c* of the Boiler Code

to deduct the rivet holes when figuring "the full strength of the plate corresponding to the thickness at the joint"?

b An interpretation is requested of Par. 201, as regards the constant in the formula for staybolts. This paragraph requires that "the spacing of the rivets over the supported surface shall be in conformity with that specified for staybolts," but we fail to find a constant which seems to fit the case.

c An interpretation is requested of the last sentence in the last paragraph in Par. 299 of the Boiler Code which is not quite clear.

Reply: a It is not the intention under Par. 184*c* of the Boiler Code to deduct the rivet holes when figuring "the full strength of the plate corresponding to the thickness at the joint."

b The constant *C* used in the formula for rivets shall be that given in Par. 199 for stays screwed through the plates with the ends riveted over. This means that *C* shall be 112 or 120 depending on the thickness of the plate.

c The sentence referred to is intended to convey the idea that fittings on pipe connections or in other fittings that are used between the main steam nozzle of the boiler and the boiler itself need not conform to the dimensions given in Tables 16 and 17.

Case No. 220

(In the hands of the Committee)

Case No. 221

Inquiry: Is it necessary under the requirements of the Boiler Code that small vertical tubular boilers such as are used for clothes-pressing, vulcanizing and laundry service, shall be fitted with gage cocks when a water gage glass is attached?

Reply: It is the opinion of the Committee that a boiler of this type that is operated with a fixed water level, should be fitted with both water gage glass and gage cocks; or two gage glasses as indicated in Par. 294.

Case No. 222

Inquiry: What is the application of the limitation of length of staybolts given in Par. 200 of the Boiler Code, that must be drilled with tell-tale holes in their outside ends? Does this length of staybolt apply to inside distance between plates stayed, or to the outside length of the bolt over all?

Reply: Par. 200 of the Code specifies that "staybolts used in waterlegs of water-tube boilers shall be hollow or drilled at both ends irrespective of their length." Par. 220*d* specifies that "the length of a stay between supports shall be measured from the inner face of the stayed plates."

Case No. 223

Inquiry: Is it necessary under the requirements of the Boiler Code to provide staying in a single flue boiler 19½ in. in diameter by 43 in. high, having a 16½ in. furnace, crown sheet of which is connected to the top head of the boiler by a 6-in. flue?

Reply: Inasmuch as the diameter of the furnace is less than 18 in., it is evident that under the requirements of Par. 239, the furnace will not require staying. There remains, therefore, only the crown sheet, top head of the boiler and the flue to be considered. Par. 203*d* or the latter part of Par. 216 are applicable to the crown sheet and top head, if formed from flat sheets. If, on the other hand, the crown sheet and top head are dished, the maximum allowable working pressure is calculated from Par. 195. Par. 241 applies to the flue.

Case No. 224

Inquiry: Is it necessary that fire-box steel of lower tensile strength than specified in Par. 28*a*, the use of which is sanctioned in Par. 28*c*, shall have a minimum carbon limit of 0.12 per cent as specified for fire-box steel in Par. 25?

Reply: The minimum carbon limit of 0.12 per cent given in Par. 25 applies to fire-box steel having a tensile range of 55,000 to 65,000 lb. per sq. in. and does not apply to steel of a lower tensile strength, the use of which is sanctioned in Par. 28*c*.

Case No. 225

Inquiry: Is it necessary under the requirement of Par. 185 of the Boiler Code to plane down to ½ in. the thickness of the shell plate and heads at head seams, or does this requirement apply to girth seams in shell plates only?

Reply: It is the intent of the Code that Par. 184 shall apply to the plates at all circumferential joints on the shell of a horizontal return tubular boiler where exposed to the fire or products of combustion. It therefore applies to a joint between the shell and the head where the joint in the shell is exposed to the products of combustion, in which case the plate is reduced in thickness if over 9/16 in. in thickness, but the flange of the head is not so reduced.

Case No. 226

Inquiry: Is not the basis of determination of the relieving capacity of pop safety valves given in Par. 274 of the new edition of the Boiler Code a misprint? The bases of 6 lb., 5 lb., and 3 lb., of steam per hour per sq. ft. of boiler heating surface for the different types of boilers, do not seem to be in line with the other data given in the Boiler Code and not in line with good practice.

Reply: The decision to base the required minimum capacity of safety valves on heating surface was made by the Committee as a result of investigation of general average of operating duty for boilers in practice, it having been found that water-tube boilers rarely exceed a condition of forcing which will evaporate more than 6 lb. of steam per hour per sq. ft. of boiler heating surface, whereas 5 lb. per hour seems to be the limit for high pressure boilers of any other type; similarly practice with boilers operated at pressures of 100 lb. and under, indicated that 3 lb. of steam per hour was a reasonably high figure. These relieving rates were therefore adopted; the provision of Par. 270 limiting the rise of pressure to 6 per cent above the maximum allowable working pressure, being ample for protection against any boiler emergency, as in case the evaporation is over the figure specified additional safety valve capacity must be added to meet this requirement.

Case No. 227

Inquiry: a Is Par. 12 of the Boiler Code intended to prohibit the use of cast iron on boiler nozzles, flanges and supporting lugs for any temperature or pressure?

b How far from the boiler are the Rules of the Boiler Code intended to apply? That is, do they cover beyond the second stop valve and do they extend indefinitely along the header and steam pipe?

Reply: a Par. 12 is not intended to prohibit the use of cast iron for supporting lugs or for boiler nozzles or flanges, provided such nozzles or flanges are not attached directly to the boiler, or used for temperatures in excess of 450 deg. fahr.

b The rules are intended to apply to the boiler structure only as far as and including the nozzles or flanges attached directly to the boiler and to the various accessories and appliances as specified. In Par. 305 of the Code, provisions are made to allow for expansion and contraction of steam mains and for the use of steam reservoirs on the steam mains in case there are pulsations of the steam currents that might cause vibration of the boiler shell plates. This paragraph is included for the protection of the boiler and is not intended to have a bearing on the general subject of design of steam mains.

Circular 79, issued by the Bureau of Standards and prepared by G. W. Vinal and H. D. Holler, summarizes the available information on dry cells as to materials and methods of construction, and presents an elementary theory of their operation.

CORRESPONDENCE

CONTRIBUTIONS to the Correspondence Departments of MECHANICAL ENGINEERING by members of The American Society of Mechanical Engineers are solicited by the Publication Committee. Contributions particularly welcomed are suggestions on Society Affairs, discussions of papers published in this journal, or brief articles of current interest to mechanical engineers.

Pumping Machinery Used by Service of Supply of American Expeditionary Forces in France

TO THE EDITOR:

On the writer's return to America you asked for a statement regarding the nature of the work upon which he was engaged in connection with water-supply problems in France. The following account is therefore sent for your consideration:

The Water Supply office of the Headquarters Lines of Communication was first located in Paris, where it continued until January 13, 1918, when it was removed to Tours. There were changes in nomenclature during the war and finally the office was under the Headquarters Service of Supply, Service of Utilities, Department of Construction and Forestry.

The work included all the water-supply problems except those at the front, which were under another closely coöperating office at the Headquarters of the Chief of Engineers, A. E. F.

I was assigned to duty in the Water Supply office late in October, 1917, shortly after arriving in Paris, and continued the work until the end of the year 1918, when I left Tours en route to the United States. During this time I was largely responsible for the general policy regarding pumping machinery. The following information on the scope of the work is based on a report submitted by an assistant, Oscar G. Goldman, First Lieutenant of Engineers:

On the entry of the United States into the world war and on the dispatch of troops to France, the question of the water supply became of great importance. This included the supplying of camps and hospitals, as well as the railroads, in many cases necessitating the development of new supplies, in some, increasing the already existing French supply, while in others, simply assuring the French supply.

The necessity for the immediate delivery of the water to the point in question meant the development of the nearest supply, either by the sinking of deep wells or by developing the supply from the nearest stream or canal.

This required the use of pumps, the type depending upon the supply utilized and the elevation to which the water had to be delivered. Another feature affecting the pump installation was the size of discharge main available, it being necessary in many cases to install two discharge mains in default of the proper size of pipe for a single line.

Pumps which were expected to be used were estimated in a general way in regard to type, quantity of water to be pumped per minute, and head against which they were to operate. These pumps were tabulated and placed on order in the United States and supplied on monthly priorities, the number requested being estimated according to expected use.

The pumps were placed in two main classes, centrifugal and piston. Several other types were also ordered such as deep-well, steam, and air-lift pumps. The following was the general list of pumps placed on order in America:

CENTRIFUGAL PUMPS		PISTON PUMPS	
Gal. per min.	Head, ft.	Gal. per min.	Head, ft.
200	40	50	150
100	75	60	175
200	75	100	200
100	150	40	460
200	150	175	460
350	250	...	...

Pending deliveries from America, orders were placed with several French manufacturers for pumps for immediate use. Also, where special pumps were required, it was intended to obtain them from French sources.

With the French manufacturers were placed orders for the following centrifugal pumps:

Capacity, gal per min.	Head, ft.	Capacity, gal per min.	Head, ft.
100	50	200	250
100	100	350	50
100	150	350	100
100	200	350	150
200	50	350	200
200	100	350	250
200	150	350	300
200	200	...	...

Piston pumps were also ordered with capacities of 25 gal. per min. (260 ft. head) and 44 gal. per min. (60, 100 and 130 ft. head, respectively).

At the beginning of the war, the pumping machinery used by the American Army was either sent to the depot at Gievres or to Is-sur-Tille and from there shipped to the various jobs. Later it was decided to concentrate all this material at Gievres for distribution.

Nearly all requisitions for pumps were handled by the Water Supply Section of the Division of Construction and Forestry, and as each one was filled a card index was kept showing the type of pumps shipped and also the conditions under which they were to be operated. The pumps thus sent out were later tabulated and in this way a fairly good estimate was arrived at showing the pumps needed or which would be required, as well as the number of each such type, assuming of course that the future demands would be similar to those of the past. It was found that 25 piston pumps and 50 centrifugal pumps were required per month, in the following quantities and sizes:

CENTRIFUGAL PUMPS			PISTON PUMPS		
No.	Gal. per min.	Head, ft.	No.	Gal. per min.	Head, ft.
15	150	100	15	60	175
7	225	100	4	25	300
15	225	150	3	50	300
13	150	200	4	100	300

Of the thirteen 150-gal. centrifugal pumps, three were used in series with another pump, thereby requiring it to be of the reinforced type. The ordinary French pump was built to stand a static pressure of 200 ft. while in the reinforced type castings were made for a static head of 500 ft.

Not many steam pumps were used for water-supply work as it was almost impossible to obtain boilers. Those of the smaller capacities were used by the Forestry Section for boiler feed pumps as a standby to injectors in the operation of the sawmills, and practically all of these were of American make. In several cases triplex pumps were used as boiler-feed standbys when steam pumps were not available.

In several of the deep wells, air-lift installations were made, in many cases of the ordinary type. In some cases a special air-working cylinder was installed, known as the Weber subterranean pump, thereby making it possible to force the water directly into the supply tank, located a considerable distance and at a higher elevation from the well. Direct-connected, straight-line, gas-driven compressors were used, mounted on wheels, with a capacity of 90 cu. ft. of free air per min., against a head of 100 lb. per sq. in.

The majority of the pump installations were belt-driven. At first fiber belting was furnished, but due to the high belt velocities it was found very difficult to keep the lacings from cutting through the holes. Later, leather belting was furnished and no further trouble was experienced.

Belt velocities on French installations usually varied between 4100 and 4500 ft. per min., with a few cases as high as 4875 ft. per min. These velocities are not considered high by the French manufacturers and it was stated by the Rateau Company that they usually signed for velocities of between 4900 and 5700 ft.

Wherever electric power was available, it was desirable to install electric-motor-driven pumps. This was not always possible, as electric motors and apparatus were very difficult to obtain in

France and those from the United States had not been received until late. When American motors were available it was not always possible to use them, due to their lower speeds. Many of the French motors supplied ran at 2850 r.p.m., full-load speed, while others were rated at 1425 r.p.m. The electric motors obtained from America had a speed of about 1000 r.p.m. and with the difficulty of obtaining pulleys it was almost impossible to use them with the French pumps.

For railroad water supply the usual installations consisted of gasoline-engine, belt-driven pumping units. In most cases these plants consisted of two or more units, an extra unit being installed as a standby, all units being of the same capacity, so that should one unit have need of repairs, the plant could still supply the needed amount of water. Where electric power was available but found to be unreliable, gas-engine standby units were installed, not of the total capacity of the entire plant, but of such capacity as to have a certain percentage of water available.

The gas engines used for most of the installations were of the high-speed automobile type. The French engines had a range of speed of from 1200 to 1500 r.p.m., while those of the stationary type had a range of 600 to 1000 r.p.m.

The French manufacturers claimed these high-speed engines had been in continuous service, being used by the armies of England and France throughout the period of the war, and had given good service, yet whenever possible the heavy-duty, or low-speed, American-made gas engines were used.

Having thus far discussed in general terms the type of pumps and power used by the American Army along the lines of communication, a few special installations will now be explained.

The number of trains, including freight and troop, passing over the roads having increased many times that before America entered the war, it became necessary to increase the railroad water supply, and in some cases install new watering points.

One of these pumping stations was located at Foecy, Department of Cher. This plant contained two centrifugal pumps made by the Rateau Company, Paris, of the PFP-28-R type, belt-driven by a Chapuis-Dornier automobile-type 15-hp. gas engine, with 4-in. single-ply leather belting, rawhide lacing being used. The amount of water required was 140 gal. per min. against a total head of 150 ft., the discharge being two 4-in. cast-iron pipe lines with a length of about 4300 ft. The water was discharged into a 50,000-gal. railroad water tank, and supplied to the locomotives through two 10-in. standpipes.

The centrifugal pumps were single-stage, diffuser type, running for the condition mentioned above at 1890 r.p.m. and requiring about 10.5 hp. at the shaft.

At Perigueux, Department of Dordogne, the pumping station located on the Dronne River consisted of two Dumont centrifugal pumps direct-connected to 15-hp. Chapuis-Dornier gas engines. Each pumping set really consisted of two pumps bolted together on the same shaft, with special fittings, so that they could either be operated in series or parallel. Operating in series at 1300 r.p.m. each pump would supply 264 gal. per min. against a head of 98 ft., while in parallel the pumps would deliver 528 gal. per min. against a head of 49 ft. In this station these pumps were operated in series. The water was supplied to a 100,000-gal. concrete reservoir through a 6-in. discharge line about 700 ft. in length and then through a 10-in. line of about 1000 feet to the reservoir. This 10-in. line was also used as the supply line to two 10-in. standpipes for supplying water to the locomotives.

For hospital supply, the pumping station usually contained more pumping units than that installed for railroad purposes. Several of the larger stations will be hereafter described.

At Allerey, Department of Saone et Loire, the maximum amount of water needed was figured at 460,000 gal. per day, the hospital being one of 10,000 beds with a crisis expansion to 20,000. Test wells were sunk in a gravel pit located about 8500 ft. from the extreme end of the hospital and it was at first expected to get all the water from this location by sinking an additional well about 200 ft. from the first. Two centrifugal pumps of the PFP-28 type, single-stage, made by Rateau Company, Paris, rated at 189 gal. per min. against a head of 207 ft., running at 2100 r.p.m., belt-driven by 20-hp. Charron automobile-type gasoline engines, were installed. Later it was determined that the needed amount of water could not be obtained from the two wells, and it was decided to install another station on the Saone River about 2200 ft. from the wells. In this station two Rateau centrifugal pumps of the PFP 28-R single-stage type were installed, rated at 150 gal. per min. against a head of 200 ft., running at 2160 r.p.m., belt-driven by a 30-hp. Bignan automobile-type gasoline engine.

The water was pumped to a 100,000-gal. concrete reservoir through a 6-in. cast-iron main as far as the hospital and from there on through an 8-in. main, which was part of the hospital distributing system, with a length of 5500 ft. In each station the pumps were to be operated so as to give 190 gal. per min. against a head of 200 ft. This necessitated speeding up the pumps of the station located on the river to about 2300 r.p.m.

At Joue-les-Tours, Department of Indre et Loire, a 2000-bed hospital was erected. Here the water was pumped from an 8-in. well about 600 ft. deep by means of compressed air to a 11,000-gal. storage tank at about 85 ft. above the top of the well, a Weber subterranean cylinder being used. The amount of water delivered was about 100 gal. per min., through a 4-in. main about 300 ft. long, the compressor used being one of the Chicago straightline 15-hp. gas-engine-driven type, rated at 90 cu. ft. of free air per min. at 100 lb. per sq. in. The cylinder was set at about 265 ft. from the top of the well. When the well was not operating the water stood at about 25 ft., but as soon as the pump was started the water level receded to about 50 ft. from the surface of the ground. The starting pressure was about 125 lb. per sq. in. at the well, while the running pressure dropped to about 108 lb.

In another deep well, driven about 25 ft. from the other to a depth of about 500 ft., an ordinary nozzle-type air lift was installed with a 2-in. discharge and a $\frac{1}{2}$-in. air line. The air was supplied from a gasoline-engine belt-driven Worthington compressor rated at 30 cu. ft. of free air per min. against a pressure of 100 lb. per sq. in. A rough test showed that about 20 gal. per min. could be obtained at the tank, and it was proposed to use this installation as a standby.

Bassens, located near Bordeaux, was one of the ports developed by the American Army. The work there consisted in building new wharves, railroad yards, camp sites, as well as a large refrigerating plant.

The supply for the docks, railroad yards and camps was supplied from two artesian wells. At the first well, two direct-connected electric-driven 26-hp. centrifugal pumps of the PFP-28-S type were installed for 395 gal. per min. against a head of 130 ft., running at 1430 r.p.m. The "S" type pumps are two single-stage pumps bolted together on the same shaft.

At the second well two PHP-20 direct-connected, electric-driven, single-stage centrifugal pumps were installed, rated at 395 gal. per min. against a head of 130 ft. at 2800 r.p.m.

The distributing system consists of 8-in. and 6-in. Universal cast-iron pipe. The first station was located almost 8000 ft. from the docks, the discharge main being 8 in. in diameter, while the second was about 5000 ft. distant, the discharge main consisting of 6-in. pipe.

For the refrigerating plant the pumping station was situated on the banks of the Garonne River, and consisted of three direct-connected, electric-driven, single-stage centrifugal pumps of the PFP-36 type, rated at 500 gal. per min. against a head of 160 ft., running at 1430 r.p.m., the motor being one of 36 hp. The discharge line was of 12-in. cast-iron bell-and-spigot pipe with a length of about 3000 ft.

The elevation of the water level varies about 21.5 ft. between extreme high and low water, and it was therefore necessary to set the pump in a concrete pit about 9.5 ft. deep, so that at extreme low water the suction lift would be about 13 ft.

The pumps used at Bassens were among a large number especially designed for each condition by the Rateau Company of Paris.

W. B. Gregory,
Major of Engineers.

New Orleans, La.

ENGINEERING RESEARCH

A Department Conducted by the Research Committee of the A. S. M. E.

The Thermal Testing Plant of The Engineering Experiment Station, The Pennsylvania State College

THE Thermal Testing Plant of The Pennsylvania State College is one of the best-equipped plants of its kind. It consists of two buildings, the generating plant and the calorimeter building.

The generating plant is a brick building 50 ft. by 18 ft. Its equipment consists of a complete 3-ton experimental refrigerating system of the compression type, and a variable-speed circulating pump for carrying the brine to the calorimeter building. The installation is such that the plant can be driven either by electricity or by steam. The observer's bench is located in this building and contains the necessary voltmeters, ammeters, rheostats, etc., for measuring the electrical heat supplied to the test box and switches and a wheatstone bridge for measuring the temperatures registered by the resistance thermometers in the calorimeter building. In addition to the apparatus listed there are two experimental house-heating boilers located in this building.

The calorimeter building is a brick building 32 ft. by 32 ft. and contains, centrally located, an outside calorimeter room of corkboard construction, 20 ft. by 20 ft. by 10 ft. high. This room is fitted with 550 ft. of 1¼-in. brine coils distributed over three sides of the room and the brine flow can be regulated by means of the circulating pump in the generating plant, to hold the temperature to within a variation of about 1 deg. fahr. The test box which has been used in the room is a 5-ft. cube of 3-in. cork board, with one side removable. Within this calorimeter room a second calorimeter room 10 ft. by 7 ft. by 10 ft. high has recently been built and since its completion it has been used for all the testing work. It is of somewhat similar construction and is fitted with 690 ft. of 1½-in. brine coils located on the four side walls and the ceiling. This inner room is so located that space is afforded in the large room for experimenting with large test boxes. This small calorimeter room is fitted with a Tagliabue thermostat which so regulates the flow of brine that the room temperature can be held within 5 deg. fahr. and in several cases no difficulty has been experienced in maintaining a temperature which has not varied a tenth of one degree for as long as three hours. The thermostat can be adjusted from the outside of this room, so as to regulate at any desired predetermined temperature. The compressed air necessary for the operation of this instrument is supplied from an adjoining engineering building. To avoid as much as possible the evaporation of the condensed moisture from the brine coils, drip pans and drain pipes have been suspended under the various coils. The test box being used at the present time is one of wood and felt construction 32 in. by 32 in. by 16 in. It has removable blanks 2 ft. square for which similar-sized blanks of the material to be tested can be substituted. The electrical heat is furnished to the inside of the box by means of a coil of manganin resistance wire which is located near the bottom of the box. A very small electric fan is used for circulating the air inside of the box. A "sandwich" heating element is also available and can be substituted for the one now in use. It consists of coils of manganin wire placed between two perforated asbestos boards 2 ft. square, and is designed to be set vertically in the center of the box and to be used without the circulating fan. Another test box is available. The heating element of this box is an asbestos cube whose six faces are mounted with manganin resistance wire, the cube being encased in a tight-fitting galvanized-iron box. Over this heating element a casing of the material to be tested is constructed, the cube being entirely encased in the "unknown" material.

Both live current and storage-battery current are available for heating the various resistance coils. Temperature measurements are taken by means of specially designed electrical resistance thermometers. Flat nickel spirals (about 1/50 in. thick and 1¾ in. in diameter) are used for temperatures near and on surfaces, and small nickel coils encased in cylindrical cases of polished metal are used for all other temperatures. These thermometers are connected to the wheatstone bridge in the generating building.

For determining the humidity in the calorimeter room a wet-and-dry-bulb thermometer is available, and so located that readings can be taken through a triple-sash glass window, and to have the readings compare with those of a sling psychrometer a current of air is blown over the bulbs by means of an electric fan until the readings become constant, a period of about three minutes being sufficient. If it is desired to determine the effect of air velocity, electric fans are available for forcing air against the surfaces of the test box.

In heat-transmission studies the method of testing finally adopted as combining rapidity and accuracy in such degree as to be consistent with the limitation of the apparatus is to raise the temperature of the test box as quickly as possible to several degrees above the required equilibrium temperature as predetermined by an approximate calculation for a given wattage. The current is then lowered and adjusted to give the required input of heat and when the temperature drops no faster than 2 deg. fahr. per reading (20 min.) the voltage is dropped about 10 per cent for one interval and then raised to the required voltage. The current from the storage battery being subsituted for the 110-volt d.c. current at this time to maintain a constant heat input. If the temperature drops slightly and then rises and practically holds its former value, there is reason to believe that the box is "saturated" and that the equilibrium value has been reached. The test is then continued for about two hours, further testing being unnecessary. Voltage, amperage and temperature observations are made every twenty minutes and humidity and brine observations every hour.

The Engineering Experiment Station of The Pennsylvania State College will be glad to coöperate in the testing work incident to the development of new insulating materials and methods and the more efficient use of those already available.

Results of tests performed in the Thermal Testing Plant of The Pennsylvania State College appear in the following publications:

Preliminary Report from the Thermal Testing Plant of The Pennsylvania State College, by J. A. Moyer, at the Third International Congress of Refrigeration. 1913.

The Effect of Velocity and Humidity of Air on Heat Transmission Through Building Materials, by J. A. Moyer, J. P. Calderwood and M. P. Helman, Bulletin 16. The Engineering Experiment Station, Pennsylvania State College; also *A. S. R. E. Journal*, November 1915.

Determining Heat Transmission of Compound Walls with Tests on Insulated Steel Car Sections, by A. J. Wood, *A. S. R. E. Journal*, January 1917.

Report on A Study of Surface Resistance with Glass as the Transmission Medium, by H. R. Hammond and C. W. Holmberg, at the annual meeting of the A. S. M. E., December 1917.

Some Recent Studies in Heat Transmission, by J. A. Wood and R. B. Fehr, *A. S. R. E. Journal*, March 1918.

Report on The Thermal Testing Plant, by R. B. Fehr, Bulletin No. 24, Engineering Experiment Station, Pennsylvania State College.

The present work of the Thermal Plant concerns a study of the comparative insulating values of the various building materials and of air spaces. The future plans include a further study of this work and a study of the insulating values of various numbers and sizes of air spaces.

Steel Research Laboratory Planned for the Carnegie Institute of Technology

Contributed by Thomas S. Barker

THE decision of a number of officials of the leading steel and engineering companies manufacturing rolling-mill machinery, to install an experimental rolling mill and Bureau of Rolling Mill Research under the auspices of the Carnegie Institute of Technology at Pittsburgh, marks not only the beginning of a radical advance in the art of rolling steel and other metals in this country, but an equal advance in the spirit of coöperation among American manufacturers which the industrial leaders have long strived to obtain, and which they recognize as absolutely necessary if this country is to retain its industrial supremacy during the coming period of reconstruction. This Bureau of Rolling Mill Research will have four distinct functions:

1 To investigate and study the physical and mechanical changes taking place in steel and other metals, and the power consumed, during the process of being rolled at various temperatures and speeds.

2 To distribute the information obtained by means of these experiments among the coöperating firms in order that they may put it into commercial use.

3 To provide laboratory facilities in which the contributing companies may conduct experiments and investigate designs of rolls for the production of new sections which they wish to place on the market.

4 To offer courses of instruction to students employed by the contributing interests and to those students who are to specialize in this field and are registered at the Carnegie Institute.

As planned at present the mill will consist of three stands of three-high rolls driven by a 500-hp. variable-speed electric motor. The drive and change-speed gears will be so arranged that any number of revolutions between 4 r.p.m. and 1000 r.p.m. may be obtained. This wide range of speeds will enable a careful study to be made of the effects of speed on power consumed, and physical properties of the steel when rolled and treated under varying conditions.

Both the mill and the drive will be equipped with a complete set of automatic recording instruments and changes in their reading under the varying conditions of rolling mill be recorded. The special stand for measuring the spreading force on rolls is to be equipped with hydraulic cylinders so arranged that the work done to overcome friction at the roll is automatically separated from the work done in rolling the steel.

Another feature of the mill will be a quick-action stop clutch. By means of this clutch the mill may be instantly stopped while a bar is passing through the rolls.

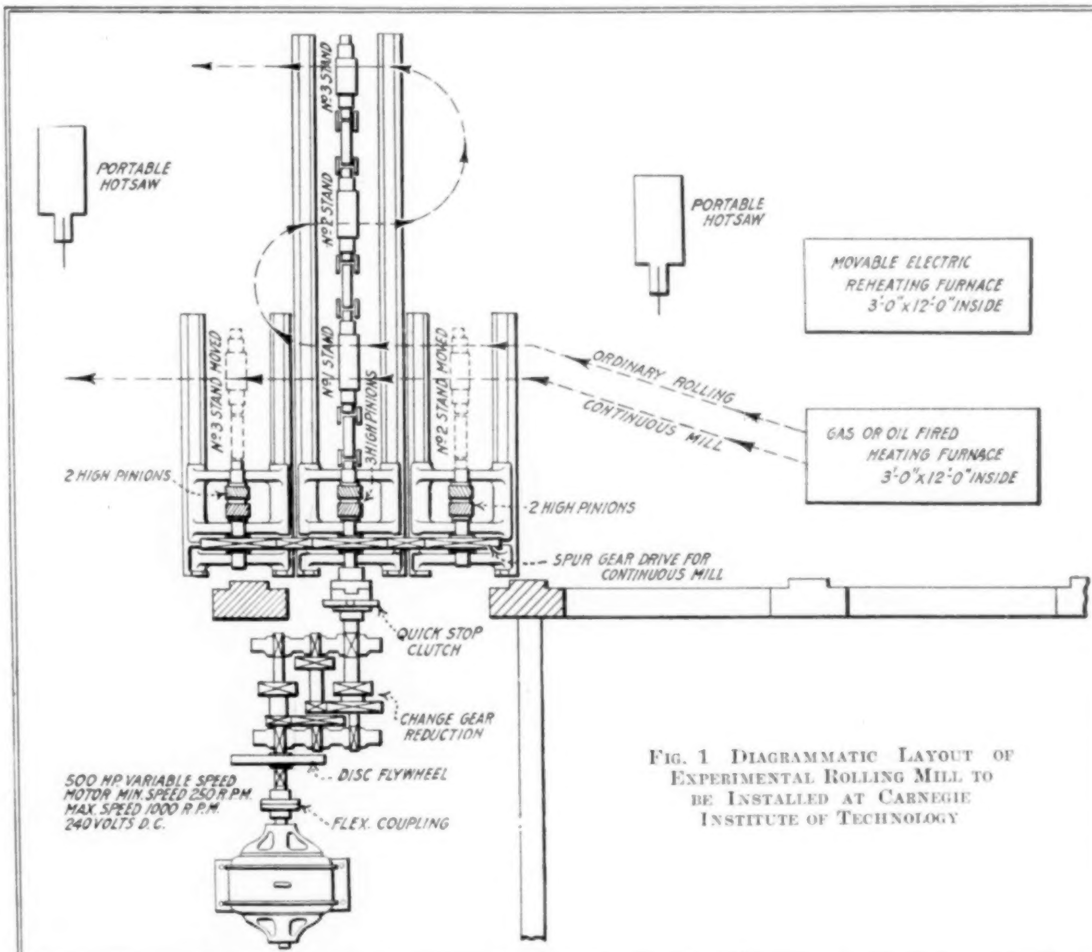

Fig. 1 Diagrammatic Layout of Experimental Rolling Mill to be Installed at Carnegie Institute of Technology

In practical mill work a roller often has to wait days and sometimes weeks before he can catch this condition, as he could not consider the stopping of production while he made a cobble in some particular roll pass that was giving him trouble, and it is mainly by studying the cobbles that the action of the steel can be observed and studied.

By stopping the mill and catching a bar in the rolls the exact action or flow of the steel in that particular pass and with the particular set of conditions under which the mill is operating, will be permanently recorded in the section of bar being pinched by the rolls.

The rolls will then be opened and the bar withdrawn and studied. By this means a student can gain more experience in the rolling of steel and knowledge of the flow of steel during rolling in one year on the experimental mill than could possibly be gained in many years' work on a commercial mill.

Fig. 1 shows a diagrammatic layout of the mill and drive. As will be seen, the three stands may be mounted on one shoe and used as a Belgian train with No. 1 as a rougher, No. 2 stand as

strand or leaders, and No. 3 stand as finishers; or No. 2 and No. 3 stands may be moved as indicated in dotted lines so that all three housings are placed in tandem and the mill will operate as a continuous mill.

When operating in this manner only the upper two rolls would be used, the lower ones being left out and the space for their neck bearings filled up. In order to drive the continuous mill a train of gears is located just outside the pinion housings, the large driving gears being mounted on an extension of one of the pinion necks. Idle gears between are carried by separate adjustable bearings.

By means of a spur gear instead of the usual bevel-gear drive used on continuous mills, the reduction ratio between the stands may be altered by changing only one gear instead of two.

In this manner it is hoped that the actual conditions existing in the mills of the contributing members of the Bureau may be easily duplicated in the laboratory, thus enabling any member to experiment on problems arising in his business under conditions which duplicate those in his mills, without excessive expense or without the losses incident to tying up a producing department.

The Bureau will be under the control of a Research Committee who will be composed of members appointed by the contributing interests, and representatives of the Carnegie Institute of Technology. This Research Committee will lay out and oversee all work and transact all business in connection with the Bureau. The entire Department is to be operated on a no-profit basis and all funds subscribed for this work and not used, will be returned to the subscribers.

Among the many problems where research work can be done and on which the information is badly needed by rolling-mill engineers, are

a Separating forces acting on rolls and housings
b Influence of speed on separating forces and on roll-train resistance
c Ratio of roll-neck friction to total roll-train resistance
d Influence of roll diameter, steel temperature, roll velocity and form of projected contact area on spreading
e Greatest deformation which plastic material can undergo without injury while being rolled.

It is planned to demonstrate to students who are studying rolling-mill engineering and roll-pass design the following phenomena:

1 Effect of separating or closing the rolls
2 Effects of "crossing" the rolls
3 Metallurgical effects of many light passes
4 Metallurgical effects of a few heavy passes
5 Rolling of shapes and merchant material
6 Study of plastic deformation and lines of flow
7 Forward slippage in rolling.

Reports Upon Research

A—Research Results

Apparatus and Instruments A1-19 Thermometers for Aeroplane Use. Describes types of construction, design, nature and amount of errors. Aeronautic Instrument Circular No. 39. Bureau of Standards, Washington, D. C. Address Director S. W. Stratton.

Apparatus and Instruments A2-19 Aeronautic Instruments. A complete mathematical theory on elastic fatigue. Circular No. 39. Bureau of Standards, Washington, D. C. Address Director S. W. Stratton.

Apparatus and Instruments A3-19 Altitude Tables. Tables for determining altitude corresponding to various atmospheric pressures, giving results in millibars and other units. Aeronautic Instrument Circular No. 3 Supplement. Bureau of Standards, Washington, D. C. Address Director S. W. Stratton.

Apparatus and Instruments A4-19 Standard cement samples for standardizing 200 mesh sieves. 180-gram containers will give enough material for three tests. These may be purchased at 25 cents each. Bureau of Standards, Washington, D. C. Address Director S. W. Stratton.

B—Research in Progress

Properties of Engineering Materials A1-19 Concrete Molds of Paper. Tests of 1:2:4 concrete made in steel molds and paper molds. Comparative tests gave similar results, showing that paper mold can be used for test samples. Bureau of Standards, Washington, D. C. Address Director S. W. Stratton.

Air B2-19 Coefficient of Friction in Air Ducts. University of Michigan, Ann Arbor, Mich. Address Dean M. E. Cooley.

Apparatus and Instruments B1-19. Profile projecting lantern with short screen distance for magnification. Bureau of Standards, Washington, D. C. Address Director S. W. Stratton.

Apparatus and Instruments B2-19 Thread-angle measurements by three-wire method. Bureau of Standards, Washington, D. C. Address Director S. W. Stratton.

Automotive Vehicles and Equipment B2-19 Car Performance Curves. The determination of values, curves of acceleration, fuel economy at various speeds and speed ranges in accordance with specifications of the Research Division of S. A. E. University of Michigan, Ann Arbor, Mich. Address Dean M. E. Cooley.

Cement and Other Building Materials B1-19 Marble. Permanent increase in dimensions due to alternate heating and cooling. Bureau of Standards, Washington, D. C. Address Director S. W. Stratton.

Cement and Other Building Materials B2-19 Plaster "Popping." A study to determine the cause of "popping" in plaster. The investigation includes the use of overburned lime, underburned lime, improperly hydrated lime and unclean sand. Bureau of Standards, Washington, D. C. Address Director S. W. Stratton.

Cement and Other Building Materials B3-19 Sand-Lime Bricks. An investigation of the time of curing of sand-lime bricks. Bureau of Standards, Washington, D. C. Address Director S. W. Stratton.

Heat B3-19 Thermal Expansion of Glass, Dental Alloys, Cements, Human Teeth and Johannsen Gages by Interference Methods. Permitting measurements within 0.06 micron (about 2 millionths of an inch). Bureau of Standards, Washington, D. C. Address Director S. W. Stratton.

Heating B1-19 Radiators, Hot-Water. Test of hot-water radiators. University of Michigan, Ann Arbor, Mich. Address Dean M. E. Cooley.

Heating B2-19 Radiators. Heating Effect as Influenced by Type, Style and Location. University of Michigan, Ann Arbor, Mich. Address Dean M. E. Cooley.

Insulation B1-19 Magnesia Heat Insulation. A continuation of the work reported at the December meeting of The American Society of Mechanical Engineers, 1918. Mellon Institute of Industrial Research, University of Pittsburgh, Pittsburgh, Pa. Address Director R. F. Bacon.

Internal-Combustion Motors B2-19 Combustion Efficiency of Automobile Engines. University of Kansas, Lawrence, Kan. Address Dean P. F. Walker.

Internal-Combustion Motors B3-19 Delivery of Power from Multi-Cylinder Engines. University of Kansas, Lawrence, Kan. Address Dean P. F. Walker.

Properties of Engineering Materials B2-19 Concrete Floor Surfaces. A test of 31 slabs subjected to actual traffic for five months, testing out magnesium fluosilicate, varnishes and paints, waxes and three other hardeners. To date the greater part of the slabs are almost free from dust and those treated with magnesium fluosilicate compounds are very hard. Bureau of Standards, Washington, D. C. Address Director S. W. Stratton.

Properties of Engineering Materials B3-19 Bearing Metals. Ex-

perimental study has been planned and submitted to manufacturers for consideration and suggestions. Bureau of Standards, Washington, D. C. Address Director S. W. Stratton.

Textile ***Manufacture and Clothing B1-19*** Asbestos Textiles. An investigation for the purpose of standardizing specifications for asbestos textiles. Mellon Institute of Industrial Research, University of Pittsburgh, Pittsburgh, Pa. Address Director R. F. Bacon.

Textile ***Manufacture and Clothing B2-19*** Investigation of Tautness of Airplane Fabrics by Means of Special Meter. Bureau of Standards, Washington, D. C. Address Director S. W. Stratton.

Transmission B4-19 Universal Joints. A study of problems of the universal joint used in automobile transmissions. University of Kansas, Lawrence, Kan. Address Dean P. F. Walker.

C—Research Problems

Apparatus and Instruments C1-19 Study of Gaging Systems in Manufacturing Plants. Bureau of Standards, Washington, D. C. Address Director S. W. Stratton.

Apparatus and Instruments C2-19 Heat Treatment and Chemical Composition of Steel for Gages. Bureau of Standards, Washington, D. C. Address Director S. W. Stratton.

Apparatus and Instruments C3-19 Screw-Thread Gages. Possible errors in screw-thread gages and discrepancies in fit of plug and ring thread gages. Bureau of Standards, Washington, D. C. Address Director S. W. Stratton.

Apparatus and Instruments C4-19 Gages. Utility of flush-pin gages and built-up snap gages. Bureau of Standards, Washington, D. C. Address Director S. W. Stratton.

Apparatus and Instruments C5-19 Gage Marking. The proper method of etching lines on gages for correctness and distinctness. Bureau of Standards, Washington, D. C. Address Director S. W. Stratton.

Apparatus and Instruments C6-19 Indicators for Machine Work. The design of indicators more sensitive and constant than those in present use. Bureau of Standards, Washington, D. C. Address Director S. W. Stratton.

Apparatus and Instruments C7-19 Gage Salvaging. The possibility of salvaging gages by electrically nickel plating gage surfaces. Bureau of Standards, Washington, D. C. Address Director S. W. Stratton.

Metal Manufactures C1-19 Lapping. A Study of Lapping Compounds to Determine Suitability for Certain Purposes. Bureau of Standards, Washington, D. C. Address Director S. W. Stratton.

Metal Manufactures C2-19 Cutting Oils. The effect of different lubricants on cutting quality of taps. Bureau of Standards, Washington, D. C. Address Director S. W. Stratton.

Metal Manufactures C3-19 Thread Grinding. The correct principles of thread grinding. Bureau of Standards, Washington, D. C. Address Director S. W. Stratton.

Metal Manufactures C4-19 Rusting of Small Steel Parts. A method to prevent rust in small steel parts, as those in a watch, without destroying the finish. Elgin National Watch Co., Elgin, Ill. Address G. E. Hunter, Gen. Supt.

D—Research Equipment

Air D1-19 Compressed-Air Plant. Large air compressor equipped for study of air through orifices and nozzles and under cooling. Johns Hopkins University, Baltimore, Md. Address Prof. A. G. Christie.

Air D2-19 Vacuum Cleaners. Equipment to test one type of vacuum cleaning machine for power, air handled and vacuum required for vacuum cleaning. University of Illinois, Urbana, Ill. Address Dean C. R. Richards.

Air D3-19 Air Compressor for Studying Problems in Air Compression. University of Illinois, Urbana, Ill. Address Dean C. R. Richards.

Apparatus and Instruments D3-19 Devices and Instruments for Measuring Radii of Profile Gages. Bureau of Standards, Washington, D. C. Address Director S. W. Stratton.

Apparatus and Instruments D4-19 Balanced Micrometer Holder for Making Diameter Measurements of Thread Gages. Bureau of Standards, Washington, D. C. Address Director S. W. Stratton.

Apparatus and Instruments D5-19 The Hoke Precision Gage Disks. Bureau of Standards, Washington, D. C. Address Director S. W. Stratton.

Carnegie Institute of Technology D1-19. Steel Research Laboratory. See Mechanical Engineering for May, 1919. Carnegie Institute of Technology, Pittsburgh, Pa. Address Thomas S. Baker.

Fuels—Gas, Tar and Coke D1-19 Gas By-Products Laboratory. Complete laboratory for studying gas production and by-products. Equipped to study all kinds of problems arising in ovens, such as low temperature, distillation of coal, coking properties, by-products and gas-forming capacities of various coals and lignites. Johns Hopkins University, Baltimore, Md. Address Prof. A. G. Christie.

Heat D1-19 Heat Transmission Through Building Materials. Cube 6 ft. on one side equipped with heating elements and thermocouples to determine heat transfer. University of Illinois, Urbana, Ill. Address Dean C. R. Richards.

Heating D1-19 Direct and Indirect Radiators with Fans, Air Washers and Thermostats. Instruments for studying problems of heating and ventilation. University of Illinois, Urbana, Ill. Address Dean C. R. Richards.

Heating D2-19 Warm-Air-Furnace Testing Plant. University of Illinois, Urbana, Ill. Address Dean C. R. Richards.

Heating D3-19 House-Heating Boilers. Several types of sectional heating boilers equipped to study problems in heating water and generating steam. University of Illinois, Urbana, Ill. Address Dean C. R. Richards.

Heating D4-19 Thermal Testing Plant. Pennsylvania State College. See Mechanical Engineering for May, 1919, page 464. Pennsylvania State College, State College, Pa. Address Prof. A. J. Wood.

Internal-Combustion Motors D1-19 Diesel Engine of 80 Hp. For investigation with different types of oil-spray nozzles and other devices for injecting fuel. Johns Hopkins University, Baltimore, Md. Address Prof. A. G. Christie.

Internal-Combustion Motors D2-19 Plant for Testing Gas Engines, Producers Using Bituminous Coal, Automobile Engines and Other Problems of Such Motors. University of Illinois, Urbana, Ill. Address Dean C. R. Richards.

Internal-Combustion Motors D3-19 Four-Cylinder Gas-Engine Direct-Connected to 75-Hp. Sprague Electric Dynamometer. Complete equipment. Apparatus arranged for testing motor fuels. Mellon Institute of Industrial Research, University of Pittsburgh, Pittsburgh, Pa. Address Director R. F. Bacon.

Johns Hopkins University D1-19 Mechanical Engineering Laboratory Equipment.

1 Gas by-products laboratory equipped to study problems in gas manufacture and the by-products thereof.

2 Spray Pond. Apparatus to study cooling of water.

3 Compressed-Air Plant. Equipment to study flow of air through orifices and nozzles.

4 Refrigeration. Fifteen-ton refrigerating system with provisions for measuring fluids.

5 Buckeyemobile. A 75-hp. buckeyemobile unit for heat-transfer tests.

6 Diesel Engine. An 80-hp. Diesel engine for studying fuel oils. Address Prof. A. G. Christie, Johns Hopkins University, Baltimore, Md.

Mellon Institute D1-19 Unit Plants. The Mellon Institute has installed small-scale complete equipments to study process development by the construction of unit plants in which the process was carried out commercially, although of smaller size than the final commercial installation. Mellon Institute of Industrial Research, University of Pittsburgh, Pittsburgh, Pa. Address Director R. F. Bacon.

Metallurgy and Metallography D1-19 Furnaces, ovens, grinders, crushers, vacuum dryers and filter presses. Mellon Institute of Industrial Research. University of Pittsburgh, Pittsburgh, Pa. Address Director R. F. Bacon.

Metallurgy and Metallography D2-19 Steel Research Laboratory, Carnegie Institute of Technology. See MECHANICAL ENGINEERING for May 1919, page 465. Address Thomas S. Baker, Secretary, Carnegie Institute of Technology, Pittsburgh, Pa.

Pennsylvania State College D1-19 The Thermal Testing Plant of the Engineering Experiment Station. See MECHANICAL ENGINEERING for May, 1919, page 464. Pennsylvania State College, State College, Pa. Address Prof. A. J. Wood.

Refrigeration D1-19 Refrigerating Plant for Accurate Determination of Ammonia and Brine Used in Refrigeration. Fifteen-ton refrigerating system equipped for weighing ammonia and measuring brine. Johns Hopkins University, Baltimore, Md. Address Prof. A. G. Christie.

Refrigeration D2-19 Compression and Absorption Apparatus for Experimental Work. University of Illinois, Urbana, Ill. Address Dean C. R. Richards.

Steam Power D1-19 Spray Ponds. Spray pond equipped with nozzle to determine the laws of cooling water by such means. Johns Hopkins University, Baltimore, Md. Address Prof. A. G. Christie.

Steam Power D2-19 Buckeyemobile of 75 Hp. for Heat-Transfer Tests. Johns Hopkins University, Baltimore, Md. Address Prof. A. G. Christie.

Steam Power D3-19. Engines and Turbines for Use with Saturated and Superheated Steam. University of Illinois, Urbana, Ill. Address Dean C. R. Richards. See University of Illinois, *D1-19.*

Steam Power D4-19 Boiler Experimental Work. Water-tube boiler equipped with chain-grate stoker with independent superheater and economizer for experimental work. University of Illinois, Urbana, Ill. Address Dean C. R. Richards.

Textile Manufacture and Clothing D1-19 Machinery for Wool Manufacturing, Including Spinning and Weaving. Installed for experimental purposes at the Bureau of Standards, Washington, D. C. Address Director S. W. Stratton.

Transmission D1-19 Belt-Testing Apparatus. Two Sprague electric dynamometers of 100 hp. each. Mellon Institute of Industrial Research, Pittsburgh, Pa. Director R. F. Bacon.

E—RESEARCH PERSONAL NOTES

Apparatus and Instruments E1-19 Gage Section—Bureau of Standards.

During the last few months the Gage Section of the Bureau of Standards has developed several new methods of making measurements of gages and gaging instruments. These include:

1 Simple methods of measuring effective pitch diameters of taper pipe-thread gages using three wires.

2 The use of light-wave interference methods for making length comparisons and for testing flatness and parallelism of surface of flat end standards.

3 Application of sliding taper parallel for measuring snap gages.

4 The use of mechanical indicator for testing plain ring gages. Address S. W. Stratton, Bureau of Standards, Washington, D. C.

Apparatus and Instruments E2-19 Gage Section—Bureau of Standards.

The Gage Section of the Bureau of Standards has made several communications which may be had under certain conditions by application to the Bureau. For the information of those interested, the following list is given:

B462—Test of Micrometer Calipers. (To be revised before distribution.)

B466—Procedure of Tests and Explanation of Reports of Munition Limit Gages by Bureau of Standards.

B467—Gage Tolerances Used by Ordnance Department, U. S. A.

B500—Inspection of Pipe Thread Gages in the Fields. (To be revised before distribution.)

B503—Course of Instructions Covering Measurement and Use of Munition Limit Gages. (Obsolete but available.)

B505—Questionnaire for Information on the Standardization of Screw Threads.

B506—Important Screw-Thread Systems.

B507—Dimensions of Briggs Standard Pipe Gages.

B511—Reminders Regarding Microscopes. (Not intended for general distribution, but obtainable on request.)

B513—Service Available at the Bureau of Standards Gage Laboratories.

B515—Formula for Determining Effective Diameter of Buttress Threads. (Not ready for distribution.)

B516—Tables of Dimensions of Foreign Threads. (Not ready for distribution.)

B517—Thread Form and Clearance of U. S. Standard Thread Gages. (Not ready for distribution.)

Address Director S. W. Stratton, Bureau of Standards, Washington, D. C.

Cement and Other Building Materials E1-19 Concrete Shear Tests.

The Editor of *Engineering News-Record* calls attention to the fact that the question of shear in concrete is in a most unsatisfactory state in spite of the number of tests which have been made on this subject. He calls attention to a series of tests described in the *News-Record* for Feb. 27, 1919, by Slater, and states that these investigations should be carried further. The Bureau of Standards is willing to carry on this work if funds may be provided for the work, and those interested might take up this matter with members of Congress for support.

General E3-19 Steel Treating Research Society.

The Steel Treating Research Society, with headquarters at Detroit, Mich., W. P. Woodsie, President, and H. G. Kiefer, Chairman of the Detroit Section, is desirous of coöperating with the Research Committee. The work of the Society is outlined from its By-Laws relative to its Standards Committee as follows:

> The duties of the Standards Committee shall be to adopt as standard, steels having the composition of the Society of Automotive Engineers Standard Steels, and to compile in suitable form all existing data regarding the physical properties and heat treatment of the same, or by the supervision of original research work, to establish as standard the heat treatment for the above steels. It shall also be the duties of the Standards Committee to collect all information regarding methods of manipulation and heat treatment and equipment with which to conduct heat treatment, and to adopt as standard the most uniform and desirable methods to obtain the standard physical properties. The work of standardization is not to be limited to automotive steels entirely, but in time may be extended to cover all types of steels and their heat treatment which are known to the art.

Heating E1-19 Heating Researches.

The American Society of Heating and Ventilating Engineers has just begun a comprehensive program of research costing $20,000 per year. Most of the work will be done in connection with the laboratories of the Bureau of Mines at Pittsburgh. No definite information has been received by the Committee on the plans for this research, but as soon as information is received it will be communicated to the Society.

University of Michigan E1-19.

The research personnel of the mechanical engineering department includes Prof. J. E. Emswiler, H. E. Keeler and H. J. Watson in general mechanical engineering and Prof. W. E. Fishleigh and W. E. Lay in automobile truck and tractor investigations.

F—BIBLIOGRAPHIES

Petroleum, Asphalt and Wood Products F1-19 Distillation of Oils and Latent Heat of Vaporization. Short bibliography. Address Library, United Engineering Society, 29 West 39th St., New York City.

ENGINEERING SURVEY

A Review of Progress and Attainment in Mechanical Engineering and Related Fields, as Gathered from Current Technical Periodicals and Other Sources

SUBJECTS OF THIS MONTH'S ABSTRACTS

Bureau of Standards
Marbles, Physical and Chemical Tests
Gasoline, Viscosity of
Silica Brick
Glasses, Eye-Protective, Transparency
Fiber
Rail Steel
Molding Sand
Stokers to Burn Coke Breeze
Colloidal Fuel
Pulverized-Coal-Oil Fuel
Elevator, Gearless Tractor
Elevator Safety Devices
Oil Engines, 2-Cycle, Port Design
Carburetor, Cox Atmos
Engine Efficiency and Outlet Water Temperature
Engine Operation at High Altitudes
Supercharging
Bessel-Clifford Function
Concrete, Measurement of Consistency
Concrete-Molding Plant, Pennsylvania Railroad Company
Steam-Boiler Firing, Patents on
Centrifugal Separation Machines, Continuous
Puddling Mill
Consolidation Type Locomotive, Philadelphia & Reading Railroad
Reinforced-Concrete Gondola Car
Wood Preservation, New Method of

AERONAUTICS (See Internal-Combustion Engineering)

BUREAU OF STANDARDS

Physical and Chemical Tests of the Commercial Marbles of the United States, D. W. Kessler. This paper is the first report of the Bureau of Standards in connection with an extensive coöperative program for investigating the building stones of the United States. The other Government departments participating in the work on different phases of the investigation are the U. S. Geological Survey, Bureau of Mines, and Office of Public Roads.

The paper comprises the results of strength tests, water absorption, porosity, specific-gravity, freezing, thermal-expansion, electrical-conductivity and chemical tests on 52 different types of marbles produced in this country. The purpose of the work is to determine the relative value of the different types for building purposes and other special uses.

Compressive-strength tests were made on specimens in the original condition and on specimens after being soaked in water for two weeks. The dry specimens have strength values ranging from 7,850 to 50,205 lb. per sq. in. As a rule the soaked specimens gave lower compressive strengths than the dry, and in a few cases the loss due to soaking was over 25 per cent.

Transverse- and tensile-strength tests are included and show the strength of the specimens when broken perpendicular and parallel to the bedding planes.

The freezing tests made for this report consisted in determining the loss in weight and strength due to 30 freezings and thawings. While these losses were considerable in most cases, some samples showed practically no loss and occasionally a gain in strength was indicated. Hence it was decided that 30 freezings were not enough to give a trustworthy indication of the durability of such materials. An apparatus has been installed which automatically shifts the specimens back and forth between a cold chamber and warm chamber at certain intervals. With the use of this apparatus it is possible to make a great number of freezings which will correspond to several years of exposure to the weather. It is proposed to make extensive weathering tests with this apparatus to determine more definitely the relative effect of frost action on the different marbles as well as other types of building stones.

Electrical-resistivity tests were made on a number of different types to determine their relative value as insulators and resistivity under different conditions of moisture. The results show a considerable range of values, indicating that there is a choice of marble for use in switchboards and allied purposes.

Measurements of the thermal expansion made on a few samples of marble in this investigation show that this material does not expand at a uniform rate even at ordinary temperatures. As the temperature is increased the rate of expansion increases, hence it is not possible to state a coefficient of expansion for marble that will hold good for any very great range of temperatures. Another peculiarity brought out by these tests was the fact that marble when expanded by heating does not contract to its original dimensions as the temperature is lowered, but retains a part of the increase permanently. A number of successive heatings show the same effect, each adding an increment of length to the specimen.

A few cases of warped marble slabs are illustrated and a discussion is made of the causes which may be instrumental in bringing about this warping. (Abstract from Bureau of Standards Technologic Paper No. 123.)

The Viscosity of Gasoline. The short-tube viscosimeters which are in ordinary use for determining the viscosity of lubricating oils cannot be used with gasoline, for which it is necessary to employ an instrument with a much longer outlet tube. The Ubbelohde viscosimeter, primarily designed for kerosenes, appeared suited to the purpose and two instruments of this type were used in determining the relation between time of discharge and viscosity in poises. By a large number of runs with water and ethyl alcohol solutions, liquids of known viscosity, it was found that:

$$\text{Kinetic viscosity} = \frac{\text{viscosity in poises}}{\text{density, g. per cc.}} = 0.0000887\ t - \frac{1.438}{T}$$

where t is the time of discharge in seconds. The published standard dimensions of the instrument give 0.125 cm. as the inside diameter of the outlet tube, and this was found to be 0.129 in the instruments tested. The time of discharge for 100 cc. of water at 20 deg. cent. (68 deg. fahr.) was found to be very close to the specified value of 200 sec. It is therefore suggested that 200 sec. should be retained as standard, but that the diameter of the outlet tube should be changed to 0.129 cm.

In dealing with highly fluid liquids such as gasoline, it is convenient to use the fluidity, or reciprocal of the viscosity in poises, in place of the viscosity. The temperature-fluidity curve is very much more nearly a straight line than is the temperature-viscosity curve. Fluidities were found for thirteen samples of gasoline and one kerosene over a temperature range from 5 deg. to 55 deg. cent. (41 deg. to 131 deg. fahr.). These tests showed that kerosenes have a lower fluidity or higher viscosity than water, while gasolines, though varying greatly among themselves are all more fluid than water. This is in agreement with the published data in regard to kerosene; the available information in regard to the viscosity of gasolines is very meager.

It is generally recognized that the gravity test is an uncertain guide to the quality of kerosene or gasoline, if taken by itself without information as to the source of crude oil. This was confirmed by the tests on gasolines, their order when arranged according to densities being quite different than when arranged according to fluidities. A fractional distillation is often used as a substitute or supplement to the gravity test, and this gives valuable information. It requires, however, more complicated

apparatus and greater skill than needed to test fluidity. Furthermore, the close relation between fluidity and vapor pressure, to which attention has been called by E. C. Bingham, points to the conclusion that fluidity may be an extremely good criterion for volatility.

Bingham gives tables for fluidities of various pure chemical compounds over a wide range of temperatures, and these tables were used to compare the fluidities of the thirteen gasolines with those of the aliphatic hydrocarbons. It was found that ordinary commercial gasoline, as now sold for use in automobiles, has a fluidity slightly less than octane. Most of the special gasolines, intended for use in airplane motors, have a fluidity between that of heptane and hexane. The temperature-fluidity curves of these gasolines were nearly straight and parallel, so that the order of the different gasolines, arranged according to fluidity, would be nearly independent of the temperature considered. It is suggested that the specification of fluidity at two temperatures might serve to define a desired grade of gasoline. (Abstract from Bureau of Standards Technologic Paper No. 125)

The Constitution and Microstructure of Silica Brick and Changes Involved Through Repeated Burnings at High Temperatures, R. Insley. With the coöperation of many of the principal American manufacturers of silica brick, petrographic and microscopic studies were made of the raw quartzite, the finished brick, and brick which had received repeated burns by actual use in kilns, coke ovens, etc., for the purpose of determining the original constitution and also components of silica brick stable under conditions of repeated burning such as it would undergo in the industries. Test cubes were also prepared in the laboratory of the Bureau of Standards according to a standard commercial mix and burned at 50-deg. intervals from 1200 deg. to 1500 deg. cent. in order to trace out the mineralogical structure changes with increasing temperature.

Quartz, critobalite, tridymite, pseudo - wollastonite (α — $CaO.SiO_2$), and glass are found to be present in silica brick. Pseudo-wollastonite and glass are never present in anything but small amounts. The proportions of the other constituents vary according to the heat treatment undergone.

Microscopical quantitative analyses of the relative proportions of the three predominant minerals were made of each brick examined. These analyses show that the longer a brick is burned at high temperatures but below 1470 deg. cent., the greater will be the amount of tridymite present.

Silica brick are usually found to have a porphyritic-like structure made up of phenocrysts and groundmass. This structure is not due to any chemical or physical action which takes place during the heating or cooling of the brick but is caused by the method of grinding the raw material, the phenocrysts being the coarsely ground pieces while the ground mass is made up of finely ground material and rock flour.

Microscopic examination shows that the first inversion is from quartz to cristobalite and begins in the groundmass. The material which is broken up in the phenocrysts by shattering due to expansion on heating is then transformed into cristobalite and rims of cristobalite form around the phenocrysts similar in appearance to the reaction rims seen around minerals in natural rocks. After long heating tridymite begins to appear in the groundmass. The crystals are at first very small and rather poorly developed but increase in size with successive burnings. Tridymite is usually present at wedge-shaped and more complicated interpenetration twins. In reburned brick the quartz phenocrysts are occasionally entirely transformed to cristobalite and sometimes even tridymite crystallites begin to appear in the phenocrysts.

The lime added in the grinding of the raw materials does not appear to aid in the bonding of the brick by the compounds which it forms but rather by hastening the inversion of the silica through its fluxing action. Most of the bonding action seems to be due to the interlocking of the cristobalite and tridymite crystals. Any glass present aids but little in the bonding.

Permanent expansion is caused by the inversion of quartz to cristobalite and tridymite. A large proportion of tridymite is desirable in silica brick since it has the larger permanent expansion and subsequent buckling of the furnace walls is reduced to a minimum.

The investigation has verified the prediction of Fenner: that with a comparatively small amount of flux quartz inverts to cristobalite, then to tridymite at temperatures where cristobalite is the unstable and tridymite is the stable modification. In the case of every brick examined cristobalite was the first inversion product to form, whether the conditions had been such as to promote much or little inversion. Moreover, the final inversion product reached after many reburnings to the temperature range where it was the stable modification, resulted invariably in the formation of tridymite. (Extended abstract from Bureau of Standards Technologic Paper No. 124)

The Ultra-Violet and Visible Transmission of Eye-Protective Glasses, K. S. Gibson and H. J. McNicholas. Many glasses are on the market and extensively advertised to protect the eyes from injurious radiant energy. Unfortunately, but little authoritative information concerning the properties of these glasses has been available. The public and even oculists and physicians have had little to guide them in selecting such glasses except the claims of makers and agents. One purpose of such glasses is to absorb the injurious radiant energy which is emitted along with the light from certain lamps as well as from welding arcs and industrial furnaces, while transmitting sufficient light for vision. They thus act as filters. Another purpose in certain cases may be to absorb part of the light so as to reduce a blinding brilliance. Glasses of different types are required for different needs. The degree to which these glasses actually fulfill their avowed purpose can only be determined by measurements of their "transmission" (i.e., the ratio of transmitted energy to the energy falling on them) for the various forms of radiant energy in question. The Bureau of Standards has made such measurements on a great number of glasses now on the American market and the results are published in this paper. (Abstract from Technologic Papers of the Bureau of Standards, No. 119)

ENGINEERING MATERIALS

Fiber. Fiber was originally developed as an insulating material and as such was widely adopted in electrical work. Since then, however, it has also found wide applications in other fields, both of mechanical equipment and such non-mechanical uses as baskets, barrels, boxes, etc.

It possesses most of the properties of the flexible and semiflexible materials and at the same time some of the desirable qualities of hard materials and metals, and as a material of construction may be considered as an intermediate between the two groups.

There are three kinds of fiber in general use, viz., two kinds of vulcanized fiber—known as hard and flexible, and horn fiber. Vulcanized fiber is made by treating specially prepared vegetable fiber (usually cotton) with strong chemical reagents, after which it is manipulated with heavy machinery to produce the two commercial forms. During the passage of the so-called paper through the chemical bath the cellulose base is hydrolized and the surface is gelatinized to such an extent that on being passed through the laminating machines a homogeneous product is produced. Horn fiber is somewhat similar to vulcanized fiber but has hemp twine (instead of cotton as in vulcanized fiber) as its base is not chemically treated. The hydrating effect produced by chemical action in the case of vulcanized fiber is approximated in the case of horn fiber by prolonged heating. It is not quite as hard and can not be made as thick as vulcanized fiber and has, therefore, a more limited field of application.

Vulcanized fiber is made in two forms, hard and flexible; the latter being restricted to such uses as pump valves, washers and gaskets. Fiber should be clearly distinguished from such insulating materials as bakelite, condensite and others which have many properties similar to those of fiber but are not fiber.

Vulcanized fiber possesses great strength, elasticity and durability. Its tensile strength varies from 10,000 to 20,000 lb. per sq. in. (as compared with 3000 to 6000 lb. for leather). Its

resistance to compression varies from 40,000 to 60,000 lb. per. sq. in. (for wood it varies from 3000 to 11,000 lb.). Its resistance to shearing varies from 9000 to 13,000 lb. per sq. in. (compared to wood, with the grain, 225 to 906 lb., to aluminum casting 12,000 and to aluminum forgings 16,000 lb.). There is no clearly defined elastic limit, but it approximates 4000 lb., and there is no permanent set even at rupture point. The specific gravity is about 1.3, varying from 1.2 to 1.5 (sp. g. of pure aluminum in a cast state is 2.58; of cork, 0.24; of wood, 0.35 to 1.33). It possesses the strength and density of a metal, yet is elastic and nearly as light as hardwood. A square foot of 1/8-in. fiber weighs about 7/8 lb., and the same area of 1-in. stock about 7 lb.; i.e., about 20 cu. in. to the pound. Fiber is usually sold by weight and the present article gives the average weights of standard sheets.

Vulcanized fiber is insoluble in all the ordinary solvents and is not affected by immersion in alcohol, ammonia, benzine or any of the animal, vegetable or mineral oils. It absorbs water freely and swells when wet but is not otherwise injured.

When heated, fiber does not melt or soften, but at a high temperature it chars and loses its elasticity. Vulcanized fiber is not brittle and will stand a great amount of pounding and rough usage. It can be machined and will take a fine polish but cannot be molded.

The original article describes and illustrates many applications (mechanical and electrical) of this material. (*Raw Material*, vol. 1, no. 1, new series, March 1919, pp. 115-120, illustrated, *d*)

New Methods of Etching Show Hitherto Undiscovered Characteristics of Rail Steel

Rail Steel. Abstract of a report of an investigation carried out under the direction of the Rail Committee of the American Railway Engineering Association, the following points of which are of special interest:

The discovery of the value of deep etching with strong acid is bringing out hitherto unrecognized defects in the interior of the rail head. The Altoona Laboratory of the Pennsylvania Railroad has for some time suspected that chemical analyses of samples from different parts of the cross-section of the rail do not give sufficient information as to its quality. Further, the usual micrographic etching solutions employed have proved unsatisfactory and definite results have been secured only when the specimens were etched for two hours in a mixture consisting of nine parts hydrochloric acid, three parts sulphuric acid and one part water, kept at 200 deg. fahr. This brought out a remarkable number of longitudinal, transverse and irregular marks or depressions, and these marks, representing streaks of more soluble materials, proved the existence of serious non-homogeneity, which hitherto could not be discovered otherwise.

In a rail that had never been in service the deep etching with strong mineral acid mixtures brought out indications of irregularity of structure, whereas picric acid etching has failed to develop anything unusual. In this connection an observation is reported by J. B. Young, chemist of the Philadelphia and Reading Railroad, whose tests indicate the likelihood that flaws and cracks may exist in new rails which have been subjected to no strains except those developed in the rolling.

The second point brought out by the research of the Rail Committee is that statistics prove that about all transverse fissures occur in rails rolled directly from the ingot, while rails from reheated blooms virtually never fail in this way. If true, this would prove that defects of the ingot rather than excessive stresses are responsible for transverse fissures. As an editorial in *Engineering News-Record* (March 27, 1919, p. 599) remarks, it may be deduced from these data that there seems to be more promise in metallurgical studies of rail steel and examination of furnace and mill conditions than in the study of track service.

Tests of rails by a magnetic tester to detect internal flaws were made by Dr. P. H. Dudley of the New York Central Lines. He gives no details as to results obtained, but states that the leakage curves of rails obtained with this apparatus furnish much information about the physical properties in rails and about the disturbance of the metal by the gag press employed in straightening it.

For acceptance tests on the Pennsylvania Railroad rails are subjected to a press bending test in addition to the regular drop test. The press is in a hydraulic machine operated by an intensifier standing alongside, and capable of exerting a pressure of 378 tons. The main ram is 16 in. in diameter and has a 12-in. stroke. The machine weighs 11 tons. The supports for the rail, under the pressure ram, may be set at various spacings; tests have been made with supports 24 in. to 51 in. apart. A hydraulic pressure indicator records on a drum turned by a connection with the main ram, so that an autographic diagram is produced.

Deflections at ultimate load of rail specimens bent in this machine are found to be an indication of the ductility of the material, just as well as is the elongation in the drop test of the rail. It is also believed that the deflection is in a measure an indication of the toughness of the rail, or rather its capacity to resist shock.

Tests made up with the head down (in tension) gave more satisfactory and uniform results than those made with the head up. In the former, breaks were obtained in nearly all cases, while with the head up the breaks were apt to be branching or irregular. Furthermore, the tests made with different lengths of span of the rail showed closer agreement between the test results and theoretical curves, for the tests with head down than those with head up.

One of the striking results of tests with the bending machine brought out in a report on the subject submitted by W. C. Cushing, chairman of the subcommittee on the quick-bend tests, is the distinct superiority in quality of the rails produced by one mill as compared with those of another. A large number of tests of 130-lb. rails from three mills, plotted to show elastic limit as ordinates and ultimate deflection as abscissæ, placed the rails from one of the three mills in a group distinctly above and to the right of the groups representing the other two mills. This comparison shows greater ductility and strength, on the average, for the rails of the first mill, though all were rolled to the same specification and the same section and weight.

In another experiment, a rail that failed in the bend test at a small deflection—in other words, was brittle—was retested after annealing, and the deflection was increased more than four times, indicating a curing of the brittleness by the heat treatment. (*Engineering News-Record*, vol. 82, no. 13, March 27, 1919, pp. 610-611, *eA*)

FOUNDRY

Necessary Properties of Molding Sand and Their Determination

The Practical Analysis of Molding Sand, P. Albert Hayes. The paper discusses sieve tests and the methods of selecting sand, and attempts to give a definition of the best usable sand. Molding sand must satisfy the three major requirements of rigidity, permeability and refractoriness, which the author further subdivides as follows:

Rigidity:
a Bond of clay; *b* Size, and shape of grain.

Permeability:
a Porosity; *b* Quantity of clay; *c* Size and shape of grain.

Refractoriness:
a Quality of clay; *b* Quantity of clay; *c* Size of grain.

Rigidity and Bond. The ability of molding sand to resist strain after forming is dependent on the shape of the sand grains and also bears a very close relation to the bond of the sand. Sharp, angular and flat-sided grains interlock and form a stronger mold than rounded grains; but, on the other hand, such interlocking reduces the freedom of escape of gases and also gives a less evenly packed mold than do round grains. Hence rigidity should be secured by the bond of the clay rather than by dependence on sharp sand.

The power of clay to keep the grains of sand together depends on its content of fatty or sticky clay. The necessity of sufficient bond in worked floor sand is often neglected. The fatness of

the clay is destroyed by contact with the hot iron in the molds and care should be exercised in shaking out the castings to see that the minimum of burned sand is returned to the pile.

Porosity and Permeability. The proper venting of sand depends both on the porosity and permeability of the sand, the former referring to the spaces existing between individual grains of sand and the latter to the shortest linear distance through the pore spaces between the grains from one side of a unit volume of sand to the other. In this connection the tempering water and amount of clay are important since a large clay content will tend to fill the pore spaces and diminish the venting qualities, while water tends to reduce the permeability. Experiments indicate that 4 per cent of water is the average requirement to give maximum strength, and increasing the tempering water 50 per cent decreases the strength 35 per cent. In this connection, the original article cites tests made from several floors on which the very much lower temperatures and thereby form fluxing materials. As a result such alkali silicates may reduce the fusing point of the mixture so that cutting of the mold takes place with excessive loss of sand and poor casting surfaces. It may also cause sintering and sticking of the material to the mold. A good check on this factor is the determination of the amount of sand used per ton of castings of a given classification. This figure varies a great deal in foundries showing that either the sand is deficient or the practice is poor.

The grain size of the sand bears a relation to the size of the casting poured, a small casting taking a finer sand than a large one.

The writer recommends the use of the so-called rational analysis which would cover the percentage of clay, quartz and feldspar, and the relative fatness or bond of the clay together with a sizing test (cp. Table 1).

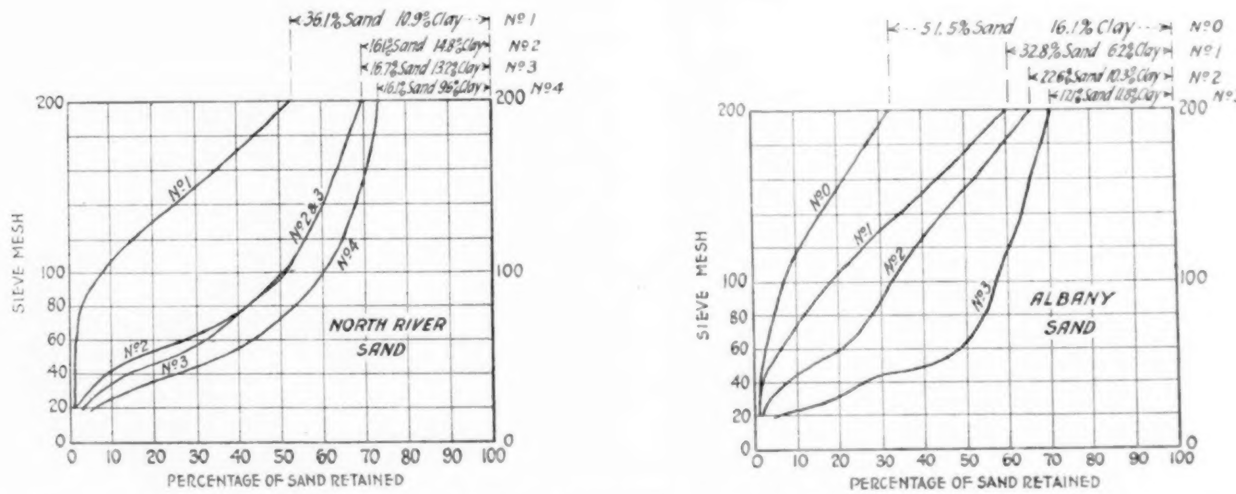

FIG. 1 GRAPHICAL STUDY OF THE RELATIVE GRAIN SIZE OF VARIOUS SANDS WHICH FACILITATES THE SELECTION OF FOUNDRY MOLDING SAND FOR THE PARTICULAR WORK IN HAND

same sand was used and the same general class of work was molded. All the sand was mixed by a sand cutter, but each individual molder tempered his own sand. The results have shown that the water content was very irregular.

Refractoriness. Refractoriness affects the ease with which the mold is broken down after use and the damaged sand is reclaimed.

TABLE 1. ANALYSIS OF SANDS, DRY BASIS

Name	North River				Albany			
	No. 1	No. 2	No. 3	No. 4	No. 0	No. 1	No. 2	No. 3
Chemical Analysis:								
Clay	10.9	14.8	13.2	9.6	16.1	6.2	10.3	11.8
Quartz	69.5	60.4	58.4	72.4	71.9	77.6	72.3	70.9
Feldspar	19.5	24.8	28.4	18.0	12.0	16.0	17.4	17.4
Iron oxide	6.7	8.5	9.8	6.2	4.1	5.5	6.0	6.0
Alumina	2.1	3.0	3.4	2.6	2.3	3.5	3.0	2.4
Physical Test:								
20 mesh	0.2	1.0	3.7	5.2	0.4	0.4	1.0	4.9
40 mesh	0.6	6.5	9.9	19.1	0.8	1.3	6.5	22.0
60 mesh	0.6	22.2	16.6	23.1	1.4	5.0	12.7	22.1
80 mesh	1.9	10.7	14.1	8.5	2.6	7.1	8.0	5.8
100 mesh	3.1	8.0	6.0	4.9	1.9	5.7	5.3	2.4
200 mesh	46.6	20.6	19.8	13.5	25.3	41.5	32.6	13.9
200 mesh	36.1	16.1	16.7	16.1	51.5	32.8	23.6	17.1
Bonding value	81.0	77.0	64.0	46.0	77.0	92.0	24.0	42.0
Moisture as received	10.5	6.5	9.1	7.3	8.6	8.2	7.8	10.0

The molding material consists of silica sand which is practically infusible, while fat clay and aluminum silicate are unchanged by the heat of molten iron except at the inner mold surface, and residual mica and silicates of the alkalies fuse at

The sieve test indicates the size of the casting for which the sand is suitable, while the other data will show the sand that will give the most rigid mold with greatest permeability and ability to stand the cutting action of the hot iron.

The accompanying curves (Fig. 1) are found by plotting the percentage of sand that will be retained by a given mesh. The perfect sand would be a straight sand parallel with the abscissa, and the nearer this condition is approached, the better the sand. Practically a sand never gains the ideal, but the graph affords very ready comparison. Many founders can grade sand to a certain extent by feel, but the writer has seen many instances of false judgment on the part of experienced men. For instance, the same sample of sand presented at two different times was graded as 1 and 2. Reference to the curves gives explanation, as the No. 1 and No. 2 sands are very similar; but the decision as rendered determined the use on certain floors. (*The Iron Age*, vol. 103, no. 12, March 20, 1919, pp. 739-741, 1 fig., *p*)

FUELS AND FIRING

STOKERS TO BURN COKE BREEZE. Description of mechanical stokers designed to burn coke breeze. These stokers contain a non-sifting grate which the designer (Joseph Harrington, Mem.Am. Soc.M.E.) emphasizes as a feature fundamentally new.

The stoker consists of cast-iron side frames carrying the driving gear, hopper, front shaft and feed gate. The grate bars overlap, giving a tortuous air passage and preventing the falling of fine fuel into the air compartment below. The bars are made of gray iron and the overlapping is secured by causing one bar to project under the overhanging part of another.

The following conditions were considered as necessary to be met before forced draft could be successfully used with coke breeze:

1 The stoker must allow the fuel to remain quiet during the

combustion period in order to avoid the formation of clinkers that cause any disturbance of the fuel bed when the ash content is in a plastic condition.

2 To avoid the accumulation of refuse in the furnace and consequent fouling of the grate surface, it must be discharged as formed, so that the ash remaining on any unit section of the grate is that which results from the burning of a single unit of fuel.

3 There must be no air spaces that are not periodically and completely cleaned by the automatic operation of the adjacent parts and disengagement of clinker which may have entered the air spaces during the previous passage through the furnace.

4 Inasmuch as the fuel bed does not require the same volume or pressure of air throughout its extent, the stoker of the future must be divided into compartments in such a manner that the air pressure and volume in each compartment are suited to the requirements of the fuel passing over the compartment.

5 To avoid the wasteful use of steam-driven auxiliaries, the stoker must be readily converted to the natural draft type during the low-load periods.

6 Parts subjected to the heat and fusing action of direct fuel contact must be readily replaceable and subjected to no mechanical stress other than its own support and the support of its portion of the fuel bed. (*Iron Age*, vol. 103, no. 13, March 27, 1919, pp. 816-817, 3 figs., *d*)

New Fuel Developed by Submarine Defense Association

Colloidal Fuel. Two articles describing experiments on colloidal fuels developed under the auspices of the Submarine Defense Association. This association was organized in June 1917 by companies representing the shipping and marine insurance interests of this and other countries to assist in developing effective anti-submarine measures and had its offices at 141 Broadway, New York City.

According to the report pulverized coal can be successfully held in suspension in fuel oil so that the colloidal liquid flows freely through pipes, preheaters and burners equipped to burn fuel oil. Months after mixing the composites showed little or no deposit. A "fixateur" which comprises about 1 per cent or 20 lb. per ton acts to stabilize the particles of pulverized coal in the oil. The fixateur and fixated oil are readily made and may be shipped anywhere. On burning, the combustion is so complete that with fair coal there is no slag and very little ash left.

Regarding the saving of cost involved in the use of this fuel, the report of the association states that, for example, with coal at $4 per ton and oil at $4 per 50-gal. bbl. the saving is $2 per ton. With coal at $5 per ton and oil at $7 per bbl. the saving is close to $6 per ton.

An interesting feature of the new development is that plants and railroads may buy from refineries any grade of colloidal fuel they desire to the prescription wanted, or they may obtain the appropriate fixated oil and make a final composition themselves. No change in oil-storage or burning equipment is required.

Another development is represented by colloidal fuel made with pressure-still residuals which hitherto have been quite neglected. From these residuals a fuel is prepared so low in sulphur that it is expected to command a premium for making higher-grade alloy steels.

A further research was started in blending petroleum oils and coal tars to see if it was practicable to stabilize the mixture so that free coke and asphaltic substances would not settle out but would produce a stable liquid fuel that could be shipped, piped and stored. The quest was well worth while because could it succeed one might so create annually here and in England up to 20,000,000 bbl. of superior liquid fuel without an increase in oil-well production. Success is now confirmed. Thus countries without oil like Australia, France, Italy and England may themselves produce over half of the substances to make liquid fuel, and as the gas-house and coke-oven tars are usually cheaper than fuel oil they will average down the cost of oil in the composite.

The experiments in making colloidal fuel were conducted at the Brooklyn plant of the Standard Oil Company. No information is given as to the nature of the fixateur besides saying that it is a heavy, black, pasty substance of the consistency of axle grease.

The fixateur, to the amount of 1 per cent of the finished product, is placed on the top screen of four horizontal screens which extend through the entire diameter of a tank, about 20 ft. high and 12 ft. diameter. The oil is entered through the top of the tank and seeps through the fixateur. The lower screens catch that part of it which oozes through the first screen, thereby holding it up where more oil can encompass it. When the oil has thus been fixated, it is introduced by pumps into the mill, which is a cylindrical tank about 2 ft. high and 3 ft. in diameter, inside of which are the mixers, consisting of arms with balls upon the ends. After the fixated oil and coal dust have been thoroughly compounded, the new mixture is pumped into storage tanks, ready to be forced into the burners.

Different grades of coal have been experimented with, ranging in ash content up to 25 per cent. An especially good carbon material has proved to be a coke containing, it is stated, 98 per cent carbon, no ash and no sulphur. The mobile paste, which is about half oil and half coal, is said to develop the largest number of heat units per unit volume of any proportion. With higher coal percentage the total B.t.u. content per gallon diminishes gradually.

Though the first experiments were conducted for marine purposes during the submarine menace, it is believed that varied uses will be found on land as well as sea in many peace-time pursuits. It is thought that colloidal fuel will be the fourth major fuel, on a par with existing solid, liquid and gaseous burning substances. Experiments are soon to be conducted in steel plants. One advantage claimed is that waste coal will be utilized with profit by the new process. (*Iron Age*, vol. 103, no. 13, March 27, 1919, p. 824, *eA*)

HOISTING MACHINERY

Gearless Tractor Elevator and Its Safety Appliances

Gearless Tractor Elevator, R. H. Whitehead. Description of an installation using the 1:1 gearless tractor-type elevator machine.

The particular feature that characterizes this type of installation is that the driving sheave and brake wheel are pressed directly on the armature shaft of the motor and hence rotate at the motor speed. The motor, therefore, must be built for very slow speeds and generally has six or eight poles wound with shunt field only. The armature is series-wound with rectangular conductors to get the largest amount of copper into the armature slots. The result is that the dimensions of the motor are several times larger than those of a machine of the same power built for a greater speed.

The matter of slippage is taken care of in the following way. The counterweight, which includes the counterweight buffer, is adjusted so that it equals the total weight of the car and sling, plus 40 per cent of the car load. Thus, for a duty of 2500 lb. the counterweight would weigh 1000 lb. more than the car and sling. With compensation as obtained by compensating ropes (Figs. 2 and 3), the maximum difference between the tension on the counterweight and the car side of the hoisting rope is 1500 lb. As the total load on both sides exceeds 16,000 lb. and as slippage does not occur until the load on one side is twice that on the other, the traction is positive; in fact, as positive as if the ropes were wound on a spirally grooved drum, which in this case would be impossible on account of the large amount of rope required due to the high rise.

The hoisting ropes are so adjusted that if the car should overrun the bottom landing the counterweights will not run into the overhead work. If either the car or the counterweight bottoms in the pit, the traction between the driving sheaves and ropes is lost, so that even if the machine continues to run, neither the car nor counterweights can be drawn into overhead work. This makes this type of machine very safe.

Compensating ropes compensate for the variation in the net load on the driving sheaves due to the shifting of the weight of the hoisting ropes from one side to the other which occurs during motion of the car up and down the hoistway. The weight of the

compensating ropes must be such per foot that they will with the electric cables leading to the car compensate for the net shifting of the load due to the weight of the hoisting ropes regardless of the position of the car in the hoistway. In addition to this a special oilspring buffer (discussed in detail and illustrated in the original article) is placed in the hoistway under the car and counterweights to assist in bringing them to rest in case the car overtravels the top or bottom landings.

An elaborate system of safety devices is provided, summed up in the following manner in the original article:

1 Automatic return of the car switch to an off position.

2 The automatic stopping switch gradually brings the car to a stop as the top or bottom landings are approached.

3 The hatchway limit switches operate if the car continues to move after the automatic stopping switch opens the reversing switches.

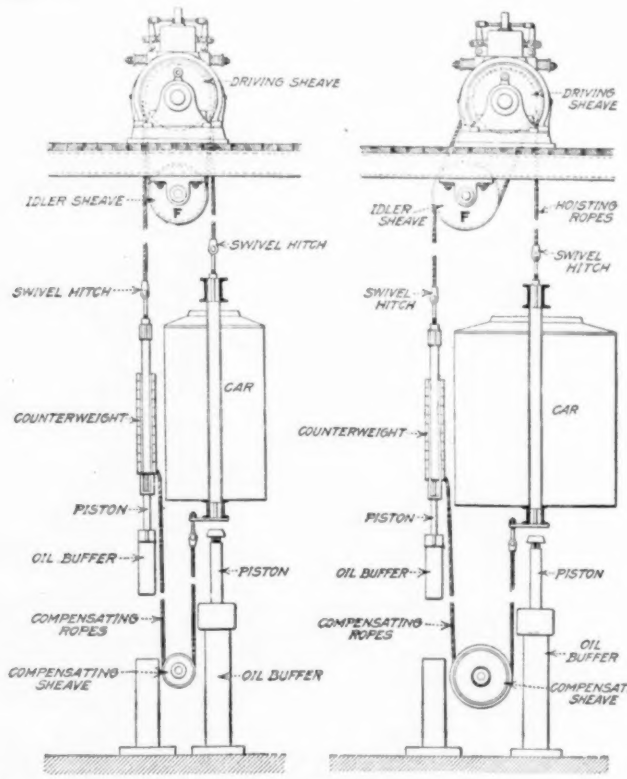

FIG. 2 INSTALLATION WHERE DRIVING SHEAVE SPANS HALF THE CAR WIDTH
FIG. 3 INSTALLATION WHERE DRIVING SHEAVE DOES NOT SPAN HALF THE CAR WIDTH

4 The switch operated by the centrifugal governor stops the car in case of overspeeding, by causing a light retarding force to be applied between the car-safety jaws and rails and opening the main potential switch.

5 The oil buffers are capable of stopping the car or counterweight at 50 per cent excess speed without discomfort to passengers.

6 After the car or counterweight strikes the bumpers, the traction between the hoisting cables and driving sheave is either lost or greatly reduced.

7 Overtravel beyond the top terminal landing lifts the compensating sheaves and housing, and this in turn helps to decrease the traction and also operates a switch to stop the motor.

8 Opening of the car-safety switch stops the motor and applies a light retarding force between the car-safety jaws and rails, thus stopping the car.

9 For high-lift elevators a mechanical retarding and latching device is provided to stop the car from overrun beyond the top-terminal landing.

10 Breaking of the hoisting ropes causes the application of a heavy retarding force on the car and counterweight safeties. (*Power*, vol. 49, no. 13, April 1, 1919, pp. 474-478, 9 figs., *d*)

HYDRAULICS

VALUES OF *n* IN KUTTER'S FORMULA FOR DIFFERENT CHANNEL CONDITIONS, C. E. Ramser. Experiments were made to determine the value of *n* in Kutter's formula on five courses of the South Forked Deer River, between Jackson and Roberts, Tenn.

The channel along these courses varied from one newly dredged and in excellent condition to a very crooked course of the old river in very bad condition, and Table 2 gives the values of *n* obtained for each of the courses for stages ranging from low to high.

The lowest values of *n* were obtained for the course of channel near Roberts (Table 2) where they were taken at periods from four to six months after the dredging of the channel has been completed. These low values may be attributed to the comparatively smooth and regular side slopes and bottom, the uniformity of cross-section and the freedom from curve or obstructions in the channel.

TABLE 2 VALUES OF *n* IN KUTTER'S FORMULA FOR DIFFERENT CHANNEL CONDITIONS

Name or type of channel	Minimum value of *n*	Maximum value of *n*
Roberts Channel (straight)..........	0.0240	0.0255
Jackson Channel (straight)..........	0.0310	0.0420
Irregular Dredged Channel..........	0.0367	0.0455
Old Straight River Channel..........	0.0500	0.0620
Old Crooked River Channel..........	0.1400	0.1620

The effect of roughness and irregularities is revealed in the results obtained for the course near Jackson. Although the channel was practically free from vegetation or obstructions of any sort, yet the values of *n* are considerably higher than those obtained for the course near Roberts. The irregularities in the lower portion of this channel were left at the time of construction, the bottom and sides of the channel never having been smoothed properly.

Still higher figures are obtained on the old straight river channel where the course is fairly straight but the cross-section variable, side slopes irregular, bottom irregular with deep holes and, what is most important, the sides are covered with trees, roots and vines and subject to caving. Here the value of *n* is roughly three times as high as in the section of channel near Roberts.

Finally the highest values for *n* were obtained in the old crooked river channel where the side slopes are very irregular, the bottom likewise very irregular and full of holes. There are many roots, trees and bushes on side slopes and many logs, large trees and other drift on bottom, in addition to which trees are continually falling into the channel due to caving banks. Furthermore, the course of the channel itself is very crooked and is made up of four distinct curves.

A comparison between the figures for the old straight river channel and the old crooked river channel is particularly instructive, since the conditions of flow except for the difference in shape of channel are rather similar and the difference in values of *n* is apparently due to this difference in the character of the course of the channel. (*Engineering News-Record*, vol. 82, no. 11, March 13, 1919, pp. 522-523, 5 figs., *et*)

INTERNAL-COMBUSTION ENGINEERING

PORT DESIGN FOR TWO-CYCLE OIL ENGINES. Discussion of a subject on which comparatively little has been published in the English language. The writer mainly considers the so-called semi-Diesel type of crude-oil engines.

The article, which is not suitable for abstracting, discusses the design of the inlet port, transfer port, and exhaust port, and gives formulæ therefor.

The writer calls attention to the fact that the designer of semi-Diesel engines should fully appreciate the necessity of getting into

the cylinder for scavenging purposes the largest amount of air possible. Not all of the incoming air remains in the cylinder and a portion of it may be driven out through the exhaust ports, allowing a corresponding amount of exhaust gas to remain in the cylinder. This loss may be taken care of in some manner and, for example, in the marine Diesel engines where scavenging air is furnished by a separate pump the displacement of the pump piston is made approximately $1\frac{1}{2}$ times that of the power piston. The design of the deflector on the end of the piston is very important in getting this air into the cylinder with the least possible loss. By a mere change in the shape of this deflector the writer claims to have seen the developed horsepower increased 10 to 20 per cent. Indicator cards of various engines are given with interesting comments on their showing. (*The Gas Engine*, vol. 21, no. 2, Feb. 1919, pp. 37-42, 5 figs., *et*)

New British Carburetor with Modified Venturi Tube

COX "ATMOS" CARBURETOR. Description of a new carburetor of British manufacture. The commanding feature of the device is a special construction of what has come to be known as the venturi tube, well illustrated in Fig. 4. It is claimed that in the usual venturi tube as the speed of the engine and hence of the air increases, the depression about the jet also increases, with the result that a relatively greater portion of gasoline than is necessary flows through the jet and the mixture becomes too rich unless special measures are provided to correct this fault.

The following explains how this difficulty is handled in the Cox carburetor. If air be drawn through the venturi tube, there comes into play at the walls of the narrow throat a fall in pressure, as at 1 in Fig. 4. The depression in this region is believed to be in strict proportion to the volume of fluid passing through the venturi. If, therefore, the jet of a carburetor be placed in a small choke tube entering the narrow throat of a venturi, then as the volume of air passing through is increased so will the depression on the jet increase in proportion. In other words, it is claimed that with such an arrangement if the mixture be set right at one point, it will remain correct over the usable range of varia-

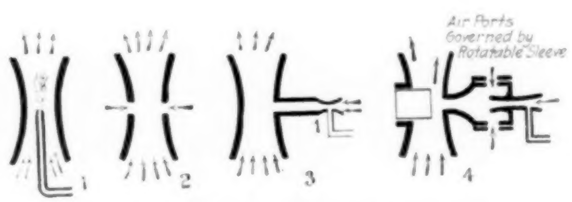

FIG. 4 DIAGRAMS ILLUSTRATING THE PRINCIPLE OF THE COX CARBURETOR

tion in volume per unit of time demanded by the different speeds of the engine. It should be borne in mind, however, that the conditions described held good only so long as the venturi preserves its shape, or, in effect, so long as the barrel throttle is wide open.

At the walls of the throat of a venturi tube there is also a region of depression, and if holes be drilled at this point (2, Fig. 4) a flow will be induced through the apertures, as indicated by the horizontal arrows. No. 3 a diagram of the carburetor at full throttle opening is shown at 3, Fig. 4. From the throat of the main venturi a pipe runs to a small subsidiary choke tube surrounding the jet. The operation with partly open throttle is shown at 4, Fig. 4. Air ports open as the throttle closes in order to prevent too great a fall of air pressure around the jet. For the sake of simplicity a piston throttle is shown in place of the barrel-type throttle actually employed.

In the Cox carburetor (Fig. 5) the middle portion of the main venturi tube is formed in the throttle barrel itself, and with partly closed throttle, therefore, the conditions of the perfect venturi tube no longer obtain, the flow of the air becoming distorted. In consequence of this, with the partly closed throttle there is a reduction of pressure in the region of the branch choke tube and the jet will be forced to deliver a disproportionately great amount of gasoline, so that the mixture will become too rich. This difficulty is overcome by the introduction of air ports in the subsidiary choke tube on the engine side of the jet. These ports are gradually opened and closed by a sleeve attached to the throttle barrel in such a way that closing the throttle opens the air ports.

Attention is called also to the consideration of the float chamber (Fig. 5). The float rises and falls upon a fixed central guide. It is separated from the needle valve and, therefore, vibration is less likely to temporarily upset the gasoline level. The needle valve is carried within a separate cylindrical duct and is operated by a single fork-ended balance-weighted lever.

A particularly important feature of the float-chamber design is the provision made to trap dirt or water. The delivery from the needle-valve duct is high up in the chamber, and the gasoline has to rise to the top of the gauze filter cylinder before it can overflow to the float chamber. At the bottom of the needle-valve duct is a passage leading to a trap chamber beneath the main float chamber. Any water or grit issuing past the needle valve falls by

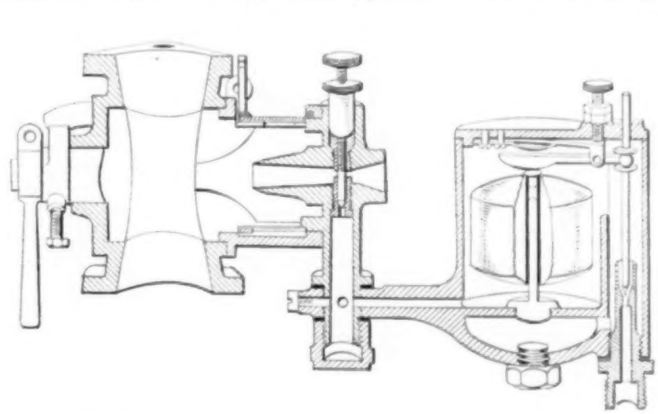

FIG. 5 SECTION IN PERSPECTIVE OF THE COX CARBURETOR

reason of its greater specific gravity into this trap chamber, whence it can be drawn out from time to time through the orifice of a detachable plug. (*The Autocar*, vol. 62, no. 1221, March 15, 1919, pp. 358-360, 4 figs., *d*)

Striking Results of Tests on Liberty-12 Engine

OUTLET WATER TEMPERATURES AND ENGINE EFFICIENCY. Data of tests (hitherto confidential) on a standard Liberty-12 engine, model A, the purpose of which was to determine how the various outlet water temperatures affect the power curve of the engine. In general, it was found that the power increases as the cooling-water temperature decreases to a point of about 100 deg. fahr. It will be noted, however, that at 90 deg. the power again begins to drop off slightly at the higher speeds. Also, the power decreases considerably with an extreme increase in temperature. At about 200 deg. fahr. the power is only 417 hp., while at 90 deg. fahr. it is 436 hp.

TABLE 3 GASOLINE CONSUMPTION OF LIBERTY-12 ENGINE AT VARIOUS OUTLET WATER TEMPERATURES

Outlet water temperature, deg. fahr.	200	170	150	130	110	90
Rev. per. min.	1600	1600	1600	1600	1600	1600
Average hp.	382	387	388	397	400	403
Lb. per hour	197.5	200	204.5	206	205.5	197.5
Gal. per hour	33.5	33.9	34.7	34.9	34.8	33.5
Lb. per hp-hr	0.518	0.518	0.527	0.520	0.516	0.490

This is well illustrated in the curves in Fig. 6. Because of the fact that the actual data of the tests are reported only in a publication not generally available, those in Table 3 are reprinted here. No information is available as to the other features of operation of the plant. Thus, for example, it is not stated whether preigni-

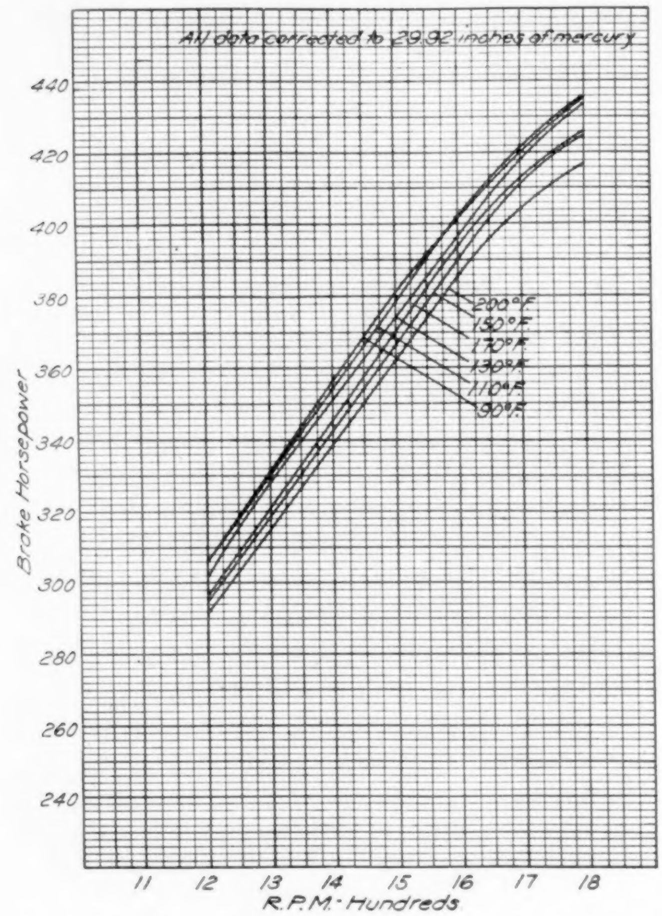

Fig. 6 Power Curves of Standard Liberty-12 at Various Outlet Water Temperatures

tion occurred at the higher outlet water temperatures. (*Technical Orders, Technical Division, Air Service,* no. 4, Jan. 1919, pp. 15-17, *e*. Secret publication, present abstract being made by special courtesy of the War Department, Air Service Engineering Division.)

Means for Increasing Power Output of Aircraft Engines at High Altitudes

Maintaining Constant Pressure Between the Carburetors of Air Engines Regardless of the Altitude, Leslie V. Spencer. It is well known that at high altitudes the power developed by the ordinary internal-combustion engine decreases materially because of the decrease of the oxygen content in the cylinder charge. The Bureau of Standards curve between the pressure and altitude at a temperature of 50 deg. fahr. shown in Fig. 7 illustrates this fact very well. From it, it appears that at 20,000 ft. an engine operates with an intake pressure of approximately half that at ground level, which affects both the proportion of the mixture and the fuel delivery through the nozzle.

In order to overcome this difficulty in the operation engineers have turned to the idea of supercompressing the air sent to the carburetor so as to maintain as nearly as possible the ground-level pressure regardless of the height. Such supercompression has been given various names, of which the present writer recommends the term "supercharging." The function of a supercharging device is, however, not to increase the normal ground-level power up to the limit in altitude for which the supercharger is designed.

In Europe the method apparently most widely used is the turbo-supercompression, a good example of which is represented by the Rateau scheme developed by Professor Rateau in France.

The rotary compressor has been tried in competition with the centrifugal type of compressor by the British at the Royal Aircraft Establishment and has been discarded in favor of the latter. The centrifugal form of compressor, however, has proved the most desirable through having a minimum of working parts, being very compact for a given capacity and being capable of operating satisfactorily at top speed over long periods of time.

As to the methods of driving the compressor, there are three possibilities. It can be direct-connected with the engine just as a magneto, possibly with a gear train to step up the speed of the compressor rotor as shown in Fig. 8.

Also the compressor might be driven by a small steam turbine, the steam being produced by the exhaust-gas heat. The third alternative is to drive the compressor impeller by means of an exhaust-gas turbine receiving its energy directly from the engine exhaust gas.

In England and Italy direct-connected means of drive through an intermediate gear train have been tried, but great difficulty was experienced in coping with the severe stresses developed in the rapidly operating mechanism due to sudden fluctuations in the speed of the engine.

Steam-turbine drive has not been seriously considered because of the obvious complications and it is the exhaust-gas drive that has found the best favor. The exhaust-gas turbine can be connected directly with the exhaust ports of the engine through special manifolds replacing the standard manifolds, so that all the

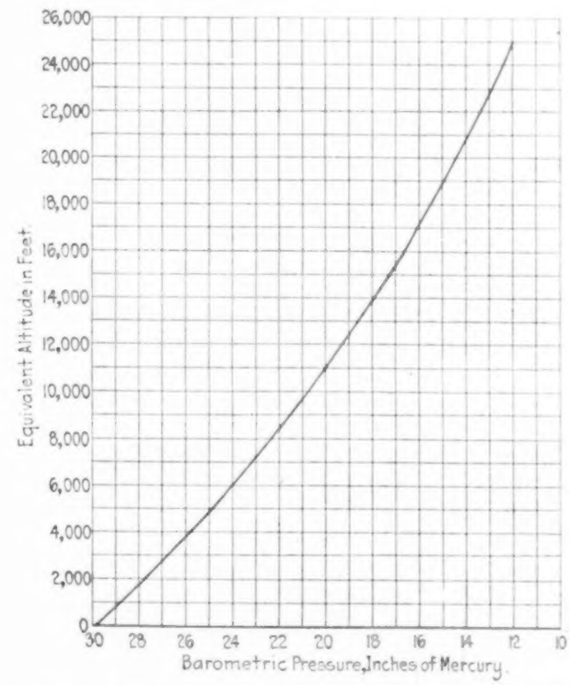

Fig. 7 Bureau of Standards Curve between Pressure and Altitude at Temperature of 50 Deg. Fahr.

exhaust must pass through the turbine nozzles and give up its energy to the turbine rotor before being allowed to escape into the atmosphere through the turbine discharge passages.

In the designs which have been experimented with thus far, the turbine rotor and the impeller of the centrifugal compressor are mounted on the same shaft so that the two are in one unit.

The general design of the Rateau supercharger can be seen from Fig. 10. The only difficulty that has been encountered is that of coping with the high temperatures of the exhaust gases, but even this difficulty seems to be close to satisfactory solution.

Around the turbine rotor there is atmospheric pressure while the supercharged engine exhausts at a normal pressure of about 30 in. of mercury corresponding to a normal atmospheric pressure of 15 lb. per sq. in. at sea level. The expansion of the gases from this pressure to that of the atmosphere is sufficient to operate the turbine at high speeds and ordinarily the turbine rotor speeds run up to 25,000 or 30,000 r.p.m.

Experiments with this system indicate that of the energy of combustion the engine and turbo-compressor utilize about 33 per

cent, whereas approximately 45 per cent is lost in the exhaust which finally escapes from the discharge ports of the turbine.

In addition to the work of Professor Rateau and other foreign experimenters a certain amount has been done in America, where at the request of the Government, E. H. Sherbondy and Dr.

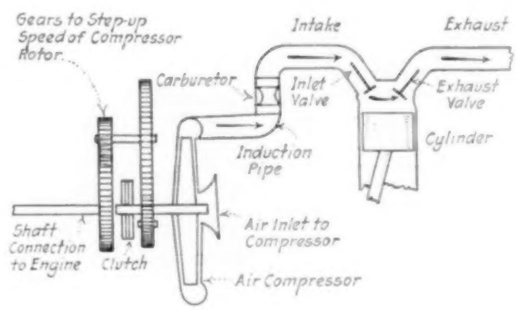

FIG. 8 DIAGRAM OF GEAR-DRIVEN COMPRESSOR FOR SUPERCHARGING

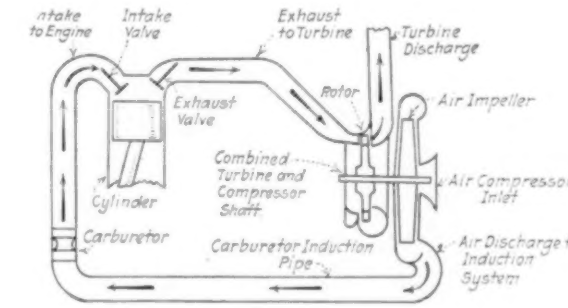

FIG. 9 THE CYCLE OF THE EXHAUST-TURBINE SUPERCHARGING SYSTEM

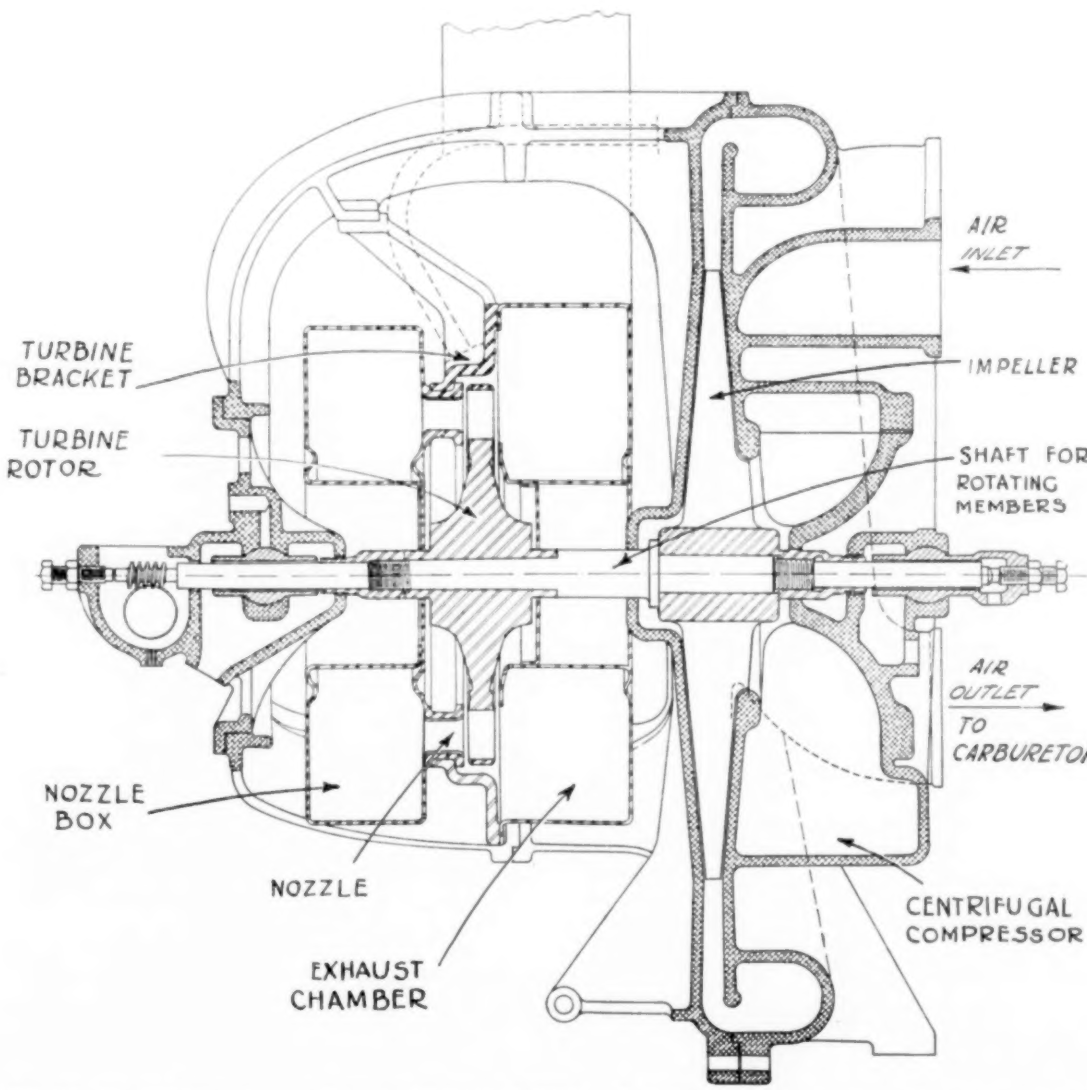

FIG. 10 CROSS-SECTION OF AN EXHAUST-TURBINE-DRIVEN SUPERCHARGER DESIGNED BY PROFESSOR RATEAU

Sanford A. Moss, Mem.Am.Soc.M.E., have taken up the same problem. The designs evolved in this country will be described in an early issue of MECHANICAL ENGINEERING. (*Aerial Age Weekly*, vol. 9, no. 5, April 14, 1919, pp. 244-246 and 264, 6 figs., *d*)

MATHEMATICS

THE BESSEL-CLIFFORD FUNCTION, G. Greenhill. Writers on stability, statical and dynamical, as of a beam, strut or whirling shaft, are compelled to introduce the Bessel function, to give a complete solution, and the ordinary function is then employed as given in the textbook.

But attention should be directed to a forgotten posthumous note by Clifford, in his Mathematical Papers, 1882, page 346, where-

he makes a start with a function, which we may denote after him by $C(x)$, obtained as the sum of all the positive integral k powers of $-x$, $(-x)^k$, divided by the square of the fractorial k, Πk, and thus

$$C(x) = \Sigma(-x)^k.(\Pi k)^2$$

but the exponential function

$$e^{-x} = \Sigma\ (-x)^k/\Pi k$$

But there is this important difference, that whereas the exponential function never vanishes, the equation $C(x) = 0$ has an infinite number of positive roots.

The nth derivative of $C(x)$ is Clifford's

$$C_n(x) = \Sigma\ (-x)^k/\Pi k \Pi\ (n+k)$$

and the nth integral,

$$\Sigma\ (-x)^{n+k}/\Pi k \Pi\ (n+k)$$

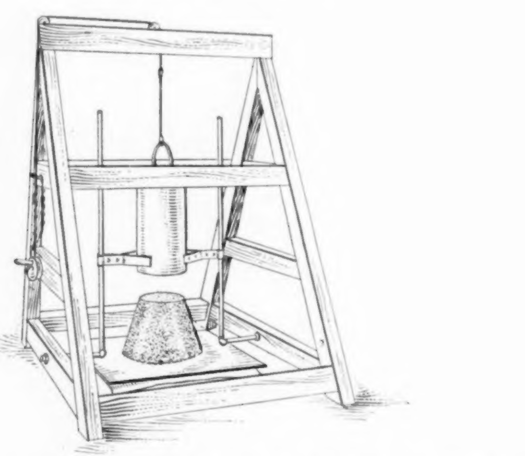

Fig. 11 Concrete Consistency Testing Machine (Showing Resulting Cone for Concrete Which Can Be Successfully Used in Practically All Ordinary Reinforced-Concrete Work)

is denoted by $C_{-n}(x)$, so that $C_{-n}(x) = x^n C_n(x)$

Thence the differential equations

(1) $d_x^{2n} x^n C_n(x) = C_n(x)$, and

(2) $d_x\,[x^{n+1} d_x C_n(x)] = x^n C_n(x)$

or $x d^2 C_n/dx^2 + (n+1) dC_n/dx - C_n = 0$;

and (3) $J_n(2\sqrt{x}) = x^{0.5n} C_{-n}(x) = x^{0.5n} C_n(x) = x^{0.5n} d^n C(x)/dx^n, J_0(2\sqrt{x}) = C(x)$

Take the problem of the uniform chain, hanging vertically and vibrating slightly, investigated on the first page of Bessel Functions, by Gray and Matthews, and again at the end of the book, where the density is taken to vary as the nth power of x the height above the lower end. To realize the experiment it is easier to revolve the chain by hand, bodily in steady motion, and to investigate the permanent shape. When the deviation from the vertical is small, it is proportional to $C(x/l)$, or $C_n(n+1)x/l$, where l is the height of the equivalent conical pendulum, and is the length of the subtangent at the lowest point, the free end of the chain. The plane vibration will be shown in the shadow of the revolving chain thrown on a vertical wall.

In the linear differential equation of the second order, reduced to the canonical form

$$\frac{1}{y}\frac{d^2y}{dz^2} + \mathrm{I} = 0,$$

where I is called its differential invariant, the solution is given by the Bessel or Clifford function when $\mathrm{I} = kz^m$; or writing it

$$z^2\frac{d^2y}{dz^2} + kz^p y = 0, p = m + 2,$$

and changing to the variable $x = kz^p/p^2$, the differential equation changes to the (2) above for $C_n(x)$, with $n = -1/p$, as in *Engineering*, page 99, January 24, by Arthur Morley. This is the differential equation required in the investigation of the vertical stability of a mast or tree, and with $m = 1$, $p = 3$, for a vertical wire or uniform rod. Here n is fractional, and in Clifford's definition Πn must be taken to mean $\Gamma(n+1)$, in Gauss' notation. Thus when n is half an odd integer, the Clifford functions are the derivations or integrals of sin $(2\sqrt{x} + a)$.

The Bessel function of real or imaginary argument, denoted by $(b\,e\,r)$ and $(b\,e\,i)$ in Kelvin's notation, are distinguished here by a mere change of sign in the argument x of the Clifford function.

To utilize the elaborate tables computed of the Bessel function, say of argument x, all that is required is a new column alongside of $x = 2\sqrt{z}$, as argument x of the corresponding Clifford function.

If writers on these questions of practical stability, which require the old Bessel function, will introduce these methods of Clifford and his function, they will notice a considerable simplification in their formulæ, and they will give to the writer of the theoretical textbook a lead he will be compelled to follow. (*Engineering*, vol. 107, no. 2776, March 14, 1919, p. 334, *t*)

MEASUREMENTS AND MEASURING APPARATUS

Method for Measuring the Consistency of Concrete, Herbert A. Davis. Description of a field instrument developed by the Concrete Ship Section, Emergency Fleet Corporation.

The apparatus consists essentially of a metal cylinder (Fig. 11) whose inside surface is perfectly smooth, mounted on metal slides that direct the movement of the cylinder so as to be truly vertical. The cylinder rests on a smooth glass plate supported horizontally and independent of the supports of the cylinder.

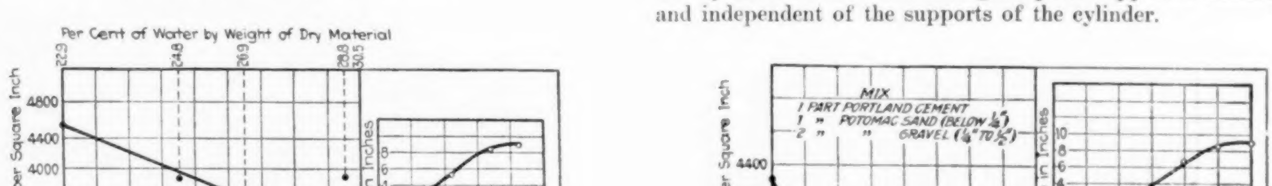

Fig. 12 Effect of Water on Concrete Consistency and Drop as Shown in Testing Machine

To operate this apparatus the cylinder resting on the glass plate is filled as a mold with the concrete, the top surface is struck off level and the metal cylinder is slowly raised, leaving the concrete unsupported. It was found that this unsupported concrete took various shapes, dependent on the amount of water used in gaging the concrete. Furthermore, over a considerable range it was noted

that the loss in height of the concrete cylinder and the removal of the metal cylinder bore a definite relation to the amount of water used in gaging the concrete.

The diameter of the resulting cone was found to be fairly reliable as a measure of consistency. Typical curves (Fig. 12) showing the relation between compressive strength, the amount of water used and the loss in height of the unsupported concrete cylinder as determined by this apparatus by two different concretes are given in the article, along with certain practical instructions as to the handling of the apparatus. (*Engineering News-Record*, vol. 82, no. 13, March 27, 1919, pp. 603-605, 6 figs, *de*)

MECHANICAL PROCESSES

Manufacture of Pre-Cast Reinforced-Concrete Members for Structural Purposes

Concrete-Molding Plant of the Pennsylvania Railroad Company. Description of a plant, the purpose of which is to manufacture pre-cast reinforced-concrete members for the erection of buildings and construction of bridges, as well as such items (fence posts, telegraph poles, etc.) as lend themselves to production in quantities at a central point. Information is also given on the erection of engine houses involving the use of elements constructed at the plant.

The fundamental idea underlying the erection of this plant is that the building of engine houses and other construction work could be facilitated by concentrating the casting of reinforced-concrete columns, roof girders, beams and similar apparatus at a central point. The site chosen was at Morrisville, Pa., just across the Delaware River from Trenton, N. J. While not exactly at the center of the road requirements for pre-cast concrete products, this site had the advantage of possessing an unlimited supply of sand and gravel peculiarly adapted to the purpose of concrete construction.

The article describes and illustrates the layout of the plant and the method of handling materials, which is of great importance in a plant of this character.

The casting operations proper are carried on in the following manner: The forms are first located on the casting platform and a shed is pushed into position to protect the work. On top of each shed are two tent houses or cupolas over bins into which concrete is deposited from the distributing tower. Leading from these beams to the forms in the building underneath are flexible delivery spouts, each capable of reaching all points within its half of the structure. A gateman stationed in each cupola through which material is being poured, operates valves to the distributing spout as may be required by the operatives on the platform and as is indicated by a system of gong signals.

A very interesting and important feature of these portable casting sheds is the heating system which has been installed in each. These consist of boiler plants located on floors suspended from the roof structure in the corner of each building, and each involving the use of a 20-hp. vertical boiler and a 150-gal. capacity water storage tank. The latter is filled by means of a hose connection to an adjacent hydrant and is of such capacity as to contain about five days' supply at each filling. The radiating coils are mounted on the side and end frames of the building and below the level of the boiler. In order to bring the returns from the heating system back to the boiler plant automatically, steam traps are used in tandem, there being about 20 lb. pressure on the line. The first of these traps collects the condensation and returns it to a point above the level of the boiler from which point the second trap returns the water to its source.

The practice is to protect the work from freezing for a period of 24 hours after pouring. By way of further protection, both from extremes of cold and excessive rates of evaporation in dry weather, large hay-filled mats are placed over newly filled forms until seasoning has advanced to the desired stage.

The articles illustrate the manner in which the various reinforced-concrete elements of construction are cast and assembled. At the outset an attempt was made to cast the roof beams and slabs in complete units, but this was found objectionable because of the unwieldiness of the completed slabs and also because their size precluded the loading of more than three on a single car. This scheme has therefore been abandoned and the plan involving individual roof beams substituted.

The erection of engine houses constructed essentially of pre-cast reinforced members is described in detail. This represents an interesting departure from what might be called standard practice, and the experience that the Pennsylvania Railroad has had is said to be such as to completely justify the experiment. In fact, the first three stalls which the road undertook to erect were set up without a hitch, as have been those since undertaken.

By virtue of the facilities described and the system of engine-house erection that has been adopted, the Pennsylvania Railroad is now in position to complete its program of enlarged engine-house facilities at a rate to which the usual method of casting columns, girders, beams, roof, slabs, etc., in place can bear no comparison; likewise a uniformly dependable quality of construction is insured and is made available at a total cost that not only justifies the plant and facilities that have been provided, but will yield a constantly increasing profit as the road continues to meet the rapidly enlarging demand for concrete structures of whatever type. (*Railway Review*, vol. 64, no. 12, March 22, 1919, pp. 425-432, illustrated, *dA*)

POWER PLANTS

New Patents Concerning Steam-Boiler Firing (Pradel, *Zeitschrift für Dampfkessel und Maschinenbetrieb*, Jan. 17, 1919). This article is the conclusion of a quarterly summary of patents relating to the firing of steam boilers. Descriptions and illustrations of the patents are given.

In the event of failure in the boiler feed pumps, the attendant must close all the boiler dampers. As information regarding pump breakdowns may often take some time to reach the boiler attendant in a large works, and as the closing of all the dampers may take a considerable time, there is a good deal of risk of an explosion occurring. To counteract this a patent (D.R.P. No. 307,490) has been taken out for an arrangement by means of which all the dampers are closed automatically as soon as for any reason the pressure in the feedpipe falls below the normal boiler pressure. Also when the maximum safe pressure is exceeded through failure of the safety valve, the dampers are closed through the pressure in the feedpipe.

Draft-regulating links for steam boiler heating must be occasionally adjusted to the steam pressure. It is also necesary to close the damper when opening the fire door so that no cooling off of the heating surface occurs. The adjustment of the regulating links to the steam pressure in the boiler, which again depends on the steam consumption, is often done mechanically. An innovation (D.R.P. No. 287,194) provides that besides the constant effect on the damper of the steam pressure, it is automatically closed when the fire door is opened, and opened fully again when the fire door is closed.

A suction smoke exhauster and cleaning device is patented (D. R.P. No. 306,668), consisting of rotating water and guide wheels and means by which the dust and gases are intimately mixed with the water.

A new apparatus for delivering and distributing the fuel on the grate is patented (D.R.P. No. 308,037), which works with a shuttle movement.

An improvement (D.R.P. No. 309,727) on a previous patent (D.R.P. No. 303,646) consists of a steam-jet tube cleaner for cleaning out locomotive boiler tubes while making a journey.

Two special spraying burners for liquid fuel are mentioned. The first is (D.R.P. No. 306,788) a further improvement of the burner, and (D.R.P. No. 296,485) has a ceramic nozzle and steel needle. The second is a revolving sprayer (patent number not given). The fuel as it leaves the nozzle is thrown sideways as much as possible, and forms a conical circle which insures the correct mixture with air being obtained. The atomized fuel and air intermingle completely, whereas in other systems on the same principle the mixture is not perfect and combustion suffers accordingly.

The last patent described (D.R.P. No. 309,345) consists of an automatic control, by means of which the liquid fuel is shut off if the boiler-feedwater supply fails. (*Technical Supplement to the Review of the Foreign Press,* vol. 3, no. 6, March 18, 1919, p. 182-183, no. 4478, *d*)

SPECIAL MACHINERY

Continuous Centrifugal Separation Machines. Description of the continuous centrifugal separator built by a South African firm. As shown in Fig. 13, it consists essentially of two vertical cylinders or bottomless buckets *A* revolving rapidly in a frame *B* around an upright spindle *C*. Each of the two buckets has an independent revolution on its own axis. The pulp or slime to be separated is fed into each bucket by a chute *D* against the outer wall, i.e., at the point farthest from the central spindle. The centrifugal force packs the solid matter of the pulp against the wall of the bucket, the fluid flowing over the upper rim and carrying the colloids with it. If desired, by lengthening the time of separation, both crystalline and colloidal solid matter may be packed against the side of the bucket and only a clear liquid is

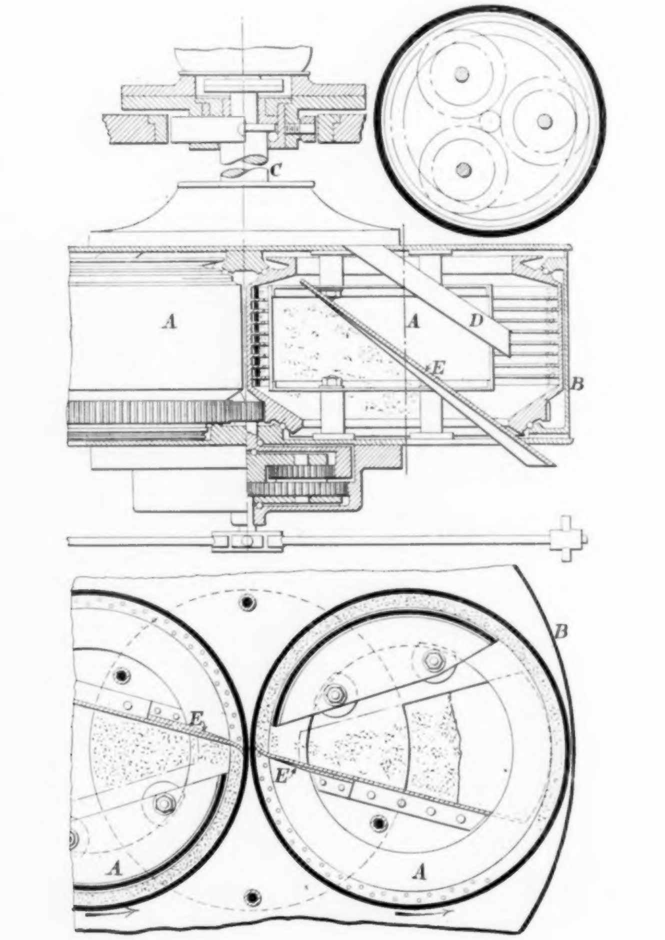

Fig. 13. Continuous Centrifugal Separator

then discharged over the rim. The slow revolution of the bucket continually carries away the clean and dry solids packed against the wall from the point of feed, so that a fresh face is constantly exposed to the feed flow. The packed solids are carried around in the bucket until they arrive at the inner wall or at the point next to the central spindle. Here the centrifugal force, which at first packed them against the wall, exercises a reverse effect and disengages them with the aid of a plow *E*, so that they fall down and out into a proper receptacle. The revolving bar of the machine is 3 ft. 6 in. in diameter. The machine is capable of treating over 25 tons of dried material per 24 hours.

It is claimed that this machine is capable of handling silver, copper, and even tin slime, of which the latter has been hitherto particularly difficult to handle. Another type of the same machine is also described in the original article. (*Engineering,* vol. 107, no. 2776, March 14, 1919, pp. 354-355, 7 figs., *d*)

New Puddling Mill at Dover, N. J. In the last few decades there has been practically no expansion of the merchant-bar-iron industry, the existing plants working mainly along the old lines. In view of this situation the erection of a new and modern puddling mill by the Ulster Iron Works, of Dover, N. J., may be considered as a very important development in the progress of this industry in the East.

The new plant now contains eleven complete double puddling furnaces and space is provided for a second similar group. The furnaces themselves are of the standard type. They burn bituminous coal under forced draft and each furnace is surmounted by a waste-heat boiler for generating steam required in the operation of the rolls and pumps and generation of electric current.

For rolling the puddle balls into blooms there is a squeezer of the rotary type. In addition an alligator squeezer was installed for upsetting the blooms. The puddle bars are rolled in an 18-in. three-high puddle train. Further refining and rolling of the puddle bars is to be carried out at the company's old plant where the equipment includes a 20-in. bar mill and other apparatus. A modern feature in the new plant is the extensive use of labor-saving devices. For delivering the puddling balls to the squeezer the old-fashioned handcar has been replaced by a monorail system. Blooms are transferred automatically from the squeezer to the puddle train. The raw materials are handled by two overhead conveyors which also remove ashes and cinder from the building.

On the other hand, however, side by side with these most modern devices is to be found the actual process of making the iron, which is the same as that discovered in 1830 by Joseph Hall, the only difference being the use of the double puddling furnace instead of the old pig-boiling process. (*The Iron Trade Review,* vol. 64, no. 11, March 13, 1919, pp. 699-701 7 figs., *d*)

RAILROAD ENGINEERING (See Also Engineering Materials)

Large Consolidation-Type Locomotives for the Philadelphia and Reading Railroad. These locomotives are notable for their weight and hauling capacity and also because they are the only engines built to a railroad company's design to be included in the 1430 locomotives ordered last year by the Railroad Administration.

They are designed for heavy drag service and are in many respects similar to the Mikado-type locomotives which preceded them. On the other hand, there are a great many differences.

TABLE 4 COMPARISON OF P. & R. CONSOLIDATION AND MIKADO TYPE LOCOMOTIVES

Type	2-8-0	2-8-2
Tractive effort, lb.	61,260	57,320
Total weight, lb.	281,100	329,300
Weight on drivers, lb.	250,800	246,600
Diameter of drivers, in.	55½	61½
Cylinders, diameter and stroke, in.	25 x 32	24 x 32
Steam pressure, lb. per sq. in.	200	225
Heating surface, total evaporation, sq. ft.	2655	4224
Heating surface, equivalent, sq. ft.	3518	5264
Grate area, sq. ft.	94.9	108
Tractive effort × diam. drivers ÷ equivalent heating surface	966.5	699.7
Firebox heating surface ÷ equiv. heating surface, per cent	8.4	6.2
Grate area ÷ vol. cylinders	5.2	6.4

As shown in Table 4, the new locomotives have smaller driving wheels and lower boiler pressure than the Mikado, but the cylinders are 1 in. larger in diameter and the starting tractive effort almost 4000 lb. greater than in the Mikado. There is also a

considerable sacrifice in heating surface, as there are eight less superheater units and 20 less tubes than in the Mikado type, and the tubes themselves are 4 ft. 2 in. shorter. For heavy drag service, however, high tractive effort at slow speeds is more important than high sustained horsepower capacity.

Because of the relatively smaller diameter of the wheels a firebox of sufficient depth can be placed above the rear drivers without raising the boiler center to an excessive height, in this instance 9 ft. 7½ in. above the rails.

The smokebox is comparatively short, and is equipped with the Economy front and arrangement, patented by I. A. Seiders, superintendent of motive power and rolling equipment of the railroad. A special feature of this arrangement is a breaker plate, which consists of a slotted plate fitted with deflecting vanes. This plate is placed under the superheater damper and in front of the tubes, and is very effective in breaking up the large sparks before they strike the netting. The netting frames are most substantial in construction, and the device has proved effective in preventing the setting of fires due to escaping sparks. (*Railway Age*, vol. 66, no. 12, March 21, 1919, pp. 760-762, 2 gfs., *d*)

GONDOLA CAR OF REINFORCED-CONCRETE CONSTRUCTION. Description of a reinforced-concrete car of the gondola type, comprising steel center sills with concrete floor, sides and ends. (See Fig. 14).

The steel skeleton body is mounted upon the standard center sills and bolsters of the United States Railroad Administration 40-ft., 50-ton gondola car. Concrete walls and floors are contained within the skeleton steel frame, and together with the reinforcement in the floor, are connected to the underframe in

FIG. 14 REINFORCED-CONCRETE GONDOLA CAR

such a manner that the buffing and pulling stresses are distributed throughout the car body. The unit stresses in the steel were limited to 16,000 lb. per sq. in. and in the concrete to 1000 lb. per sq. in.

The car has an overall length of 41 ft. 6½ in. and overall width of 10 ft. 2⅞ in., with sides 4 ft. 10½ in. high. The concrete work on this car represents the first commercial application of a light-weight aggregate known as Haydite. It is stated that this material was developed by Stephen J. Hayde of Kansas City, Mo., but no information as to the process is given. *Railway Age*, vol. 66, no. 12, March 21, 1919, pp. 776-777, 3 figs., *d*)

A NEW METHOD OF PRESERVING RAILWAY TIES. The method described by the author consists first in drying the ties and sealing them against moisture.

Essentially, an attempt was made to use the same process that nature does but faster than nature unassisted can accomplish the work. An effort was made to dissolve, neutralize or wash out the sap or other liquids or semi-liquids which obstruct and close the pores, and to do this warm vapor, or, in other words, warm saturated air with moisture is circulated among the ties. This opens and cleans the pores in the wood. Further, the liquid components of the saps and resins filling the vesicles expand with the heat and force their way out to be diluted and carried away by the warm vapor. After some hours of this treatment the amount of moisture is reduced by very slow degrees until at the end it is practically dry and the timber is removed with not more than 5 per cent of moisture left in it. Care is taken not to let the temperature of the kiln get above 160 deg. fahr. so that no injury may be done to the fiber of the wood.

The author believes that so long as the timber so treated is kept dry, it is indestructible except by fire. The elements of decay being entirely removed from the inside, all that is necessary is to keep them from entering from the outside and to do this some waterproofing coating, preferably a cheap one, is desirable.

In the experiments conducted a heavy oil tar was found which is an almost worthless by-product of refineries. The ties were merely dipped in a hot bath of this material for a few minutes and on coming out were sanded by a sand blast to absorb any superfluous stickiness and make them easier to handle.

One of the prospects opened up by this new process is the possibility of using for ties, timbers which cannot be used now. For instance, the northern birch is a strong, reliable and hard wood which cannot be used for ties or bridge timbers on account of its superabundant sap and consequent tendency to rot rapidly. Poplar and balsam belong to the same category. All of these and other similar timbers, it is claimed, can be employed when treated by the process described here. (*Railway Age*, vol. 66, no. 13, March 28, 1919, pp. 849-850, *eA*)

VARIA

ZIRCONIUM AND OTHER STEELS. In an interesting editorial *The Iron Age* calls attention to the fact that steel containing zirconium promises to play an important role in the future metallurgy of the steel industry.

Information has been published recently in France regarding some of the properties of zirconium steel. From this it appears that such steel not only possesses a very high tensile strength and an elastic ratio of over 85 per cent, but also in toughness surpasses any other steel hitherto made.

The chief difficulty in this connection had evidently been, and still is, the production of uniform ferrozirconium, one containing definite amounts of the metal and correspondingly regular amounts of other ingredients or the absence of them, and it is evident that until such ferrozirconium is secured definite scientific progress will be impossible.

Considerable concern is reported as to the future supply of vanadium. In view of the rapid exhaustion of present resources it may be necessary to find a substitute for this important alloying metal. It is hoped that this may not be the case, for the value of vanadium has been eminently demonstrated. However, should the need come, it may develop that zirconium or titanium can take the place of vanadium to a greater or less degree. Already the interest in titanium as an alloy in steel has been active and unusual results are reported from its value as an alloy in steels and not simply as a cleanser.

The zirconium steel which has given the best results in France is stated to have the following composition and physical properties:

Carbon	0.42 per cent
Manganese	1.00 per cent
Silicon	1.50 per cent
Nickel	3.00 per cent
Zirconium	0.34 per cent

Tensile strength....198 kg. per sq. mm. (281,560 lb. per sq. in.)

Elastic limit....169 kg. per sq. mm. (240,320 lb. per sq. in.)

Brinell hardness....470 (weight of 10-kg. ball making an impression 2.8 mm.)

(*The Iron Age*, April 17, 1919, p. 1030, *g*)

Articles appearing in the Survey are classified as *c* comparative; *d* descriptive; *e* experimental; *g* general; *h* historical; *m* mathematical; *p* practical; *s* statistical; *t* theoretical. Articles of especial merit are rated *A* by the reviewer.

MECHANICAL ENGINEERING

THE JOURNAL OF THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS

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Contributions of interest to the profession are solicited. Communications should be addressed to the Editor.

Members of the Society who participated in the enjoyable trip to England in 1910, and who remember with the greatest pleasure the hospitality extended by Capt. A. E. S. Hambelton of the SS. *Celtic* who conducted the party across, will regret to learn of the Captain's serious injury as a result of having been struck by an auto truck. Captain Hambelton is in Bellevue hospital where he has been confined for ten weeks, but is making a good recovery and hopes to be about again soon, although as yet he is still incapacitated.

Reunion of "Eighty-niners"

American Society of Civil Engineers
American Institute of Mining Engineers
American Society of Mechanical Engineers
American Institute of Electrical Engineers

Thirty years ago a party of American engineers, with members of their families, belonging to the four national engineering societies, sailed for Europe visiting England and the Paris Exposition of 1889, and being the recipients of many high courtesies, official, professional and individual.

Plans have been made for a Reunion Dinner, to be held in New York City, about May 26, at which it is hoped that all the survivors, ladies as well as men, of that memorable trip may meet again.

While the records of the various societies furnish an approximately complete list of the party, it is possible that some have been overlooked, or that addresses require correction.

It is therefore urgently requested that any one who was of that party communicate immediately with the Secretary of the Committee, Mr. Jesse M. Smith, Engineers' Club, 32 West 40th Street, New York, N. Y. This information is desired from every member of the party, whether attendance at the function is possible or not; those who cannot come will be heartily remembered when their letters are read.

It is hoped that the response to this request will be immediate and complete; the time is brief and the information required important.

Announcement of the precise date and place, and full details, will be sent to every individual who can be reached. Send in your name now and resolve to come to meet your traveling companions of thirty years ago.

Henry R. Towne, *Chairman.*
Jesse M. Smith, *Secretary.*

April 15, 1919.

Federal Board of Vocational Training

The great difficulty encountered by the Government in reeducating disabled soldiers and sailors is to acquaint them with the opportunities available. The ignorance of the average man regarding the Government and what it stands ready to do for him is most amazing. There are many men now in civil life, badly handicapped by injuries received in the war, but nevertheless endeavoring to work. In the hope that the condition of these men may be somewhat alleviated the Federal Board for Vocational Training has issued a notice giving full particulars regarding vocational training which is supplied free of cost, and with compensation during training based on the amount to which a man would be entitled under the War Risk Insurance Act. Further information is given regarding the supplying of artificial limbs or other appliances, and, if needed, medical treatment.

All disabled soldiers and sailors who desire aid should address their communications either to the Federal Board of Vocational Training at Washington, D. C., or to the District Offices located in Boston, New York, Philadelphia, Washington, Atlanta, New Orleans, Cincinnati, Chicago, St. Louis, Minneapolis, Denver, San Francisco, Seattle and Dallas.

Sir Robert Hadfield Prize

Sir Robert Hadfield, D.Sc., F.R.S., has placed in the hands of the British Institution of Mechanical Engineers the sum of £200, the income from which is to be awarded at the discretion of the Council of the Institution as a prize or prizes for the description of a new and accurate method of determining the hardness of metals, especially of a high degree of hardness. Ordinary tests are described in the Report of the Hardness Tests Research Committee (Proceedings of the Institution of Mechanical Engineers, 1916, pp. 677 to 778) and should be consulted by all competitors. Any tests offered should be a description of a method suitable for metallurgical work, and which can be used to determine accurately the degree of hardness in cases where present methods fail. The offer will be withdrawn January, 1922, and communications prior to that time should be addressed to the Secretary, The Institution of Mechanical Engineers, 11 Great George St., Westminster, London, S. W. 1.

Screw Thread Commission

The Screw Thread Commission, which has been extended until March 21, 1920, by an act of Congress passed February 28, has recently circulated a questionnaire relative to Acme threads. Information is desired regarding the sizes and extent of use of Acme threads in order that a tentative standard may be prepared. The standard is to include a series of pitches and diameters, and manufacturers and others interested can be of great service in this connection by answering promptly the questions below.

Replies should be forwarded to the Gage Section, Bureau of Standards, Washington, D. C., giving name, position, name of firm or organization, nature of product manufactured, street address and city.

1 To what extent do you produce or use Acme screw threads in your manufactured product? Give details as to the nature of your requirements for Acme threads.

2 Have you adopted, or are you using, any standards with reference to specified pitches corresponding to fixed diameters? If so, state sizes and pitches.

3 If you have no established standard, what sizes (diameters and pitches) would suit your regular needs? This information can be transmitted by detailed blueprints.

4 To what extent would a standard series of Acme threads benefit your manufacturing conditions?

5 To what accuracy is it necessary to produce Acme threads meeting your requirements? If you are working to definite tolerances on pitch diameter, lead, and angle, it is requested that details of this information be furnished.

SPRING MEETING OF THE A. S. M. E.

As previously announced, the Spring Meeting this year to be held at Detroit, June 16 to 19, inclusive, begins on Monday of the week of the convention instead of on Tuesday, the usual day for the opening session. Both the Committee on Meetings and Program, which has general charge of the convention and arranges the professional program, and the Detroit Local Committee, have plans well matured which are of such a character as to awaken the greatest interest and enthusiasm on the part of the membership. The attendance is sure to be large and every member who can do so is urged to take advantage of this unusual opportunity to meet so large a number of the engineers of the country and to enjoy and profit by the attractive features which the Detroit Committee are arranging for their guests.

Hotel Statler, Headquarters of the A. S. M. E. Spring Meeting, June 16-19

Rooms Should Be Reserved at Once

The headquarters for the meeting will be at the Hotel Statler where reservations should be made as early as possible. For the convenience of guests the following rates are given by the Hotel Committee, both for the Statler and the other leading hotels of the city:

Hotel Statler: \$2.00 to \$2.50 (limited in number)
3.00 (a few available)
3.50 (plenty available)
5.50 and up, rooms with double beds (plenty available)

Hotel Pontchartrain: \$2.00 up (rooms getting scarce for June)
Hotel Tuller: \$1.75 up (rooms scarce for June)

General Arrangements

The General Committee at Detroit having in charge the local arrangements is headed by H. H. Esselstyn, Commissioner of Public Works, with whom are coöperating Ralph Collamore, Vice-Chairman, Fred H. Mason, Secretary and Treasurer, and other members comprising this Committee, besides sub-committees on Reception, Hotels, Transportation, Finance, Entertainment, Printing, etc., and the Women's Committee, of which Mrs. F. G. Ray is Chairman.

A feature of the meeting will be a session in charge of the regular Detroit Local Committee, of which Mr. E. C. Fisher is Chairman. Papers will also be contributed by the Local Sections at Chicago, Cincinnati, Cleveland, Atlanta and possibly by others.

The Research Committee of the Society which is now so active in collecting and publishing in Mechanical Engineering research data regarding the work of the various laboratories of the country, will have charge of one session and the Gas Power Committee of another, taking up the subject of oil engines. A general session of interest to every member regardless of his specialty of engineering will be devoted to Industrial Relations, at which there will be addresses by prominent men in the industrial field discussing the relations existing between employers and employees under the present conditions and what must be done in order to preserve industrial peace.

As announced more fully in Section 2 of this number, plans are being made for a very attractive excursion, partly by boat and partly by rail, for those going to Detroit from the East. A blank is provided with this announcement which all who contemplate going on this excursion are requested to fill in.

Among the many social functions contemplated by the Detroit Committee are two of unusual interest in which all will wish to participate. One of these is an afternoon and evening on the Lake, which occurs on Wednesday, June 18, with a trip across Lake St. Clair and the St. Clair Flats—the "Venice of America"—on the boat *Britannia*. There will be music and dancing, and dinner will be served.

On Tuesday evening a social evening is planned, preceded by a lecture of popular interest, after which there will be music, dancing and refreshments. The ladies will be invited to enjoy a visit to Belle Isle, Detroit's beautiful playground, to participate in automobile trips, a visit to the Country Club, etc.

A Glimpse of Detroit's Fine Office Buildings Near Headquarters at Hotel Statler

Outline of Program.

Monday, June 16: Opening of headquarters and registration. Business meeting in the afternoon, followed by a general meeting at which the Committee on Aims and Organization

will make a preliminary report. This will cover one of the most important matters which has yet come before the Society, in that it involves a discussion of the aims and purposes of the Society and its work. In the evening there will be an informal reception at the hotel.

Tuesday, June 17: Research Session in the morning and Industrial Relations Session in the afternoon. Social evening with lecture, music and dancing. Should it be necessary, the professional sessions on this day will be paralleled by others at which papers offered by the Local Sections or by individual members will be presented.

Wednesday, June 18: In the morning, a session in charge of the Detroit Local Committee and Miscellaneous Session. Afternoon and evening, boat trip and dinner on the Lake.

Thursday, June 19: In the morning, Gas Power Session and Miscellaneous Session. Excursions in the afternoon.

For particulars regarding the proposed excursion to Detroit from the East, by boat and rail, with return blank for those to fill out who expect to go on this excursion, see inside front cover of Section Two of this number. Special cars will leave Eastern cities on Friday evening, June 13. Entertainment and short excursions will be provided both in Buffalo and Cleveland for those arriving in those cities on Saturday, and on Sunday both contingents will meet and continue by boat to Detroit.

Manufacture of Precision Gage Blocks at the Bureau of Standards

REFERENCE was made in the March number of MECHANICAL ENGINEERING (p. 289) to the sets of precision gages completed at the Bureau of Standards with an accuracy of a few millionths of an inch. H. L. Van Keuren, Chief of Gage Section of the Bureau, has published in *American Machinist* of April 3, an account of the process for manufacturing these gages, which are the invention of Maj. William E. Hoke.

One of the first problems was the selection of a material which would combine a suitable coefficient of expansion with permanency, wearing qualities, resistance to corrosion, susceptibility to high polish, ease of machining and uniformity of structure. Many possibilities suen as agate, fused quartz, stellite, invar, pack-hardened machine steel and tool steel were given very careful consideration; but as in practically every case these precision gages are used for verifying other gages which are of steel or pieces and parts made of steel, the convenience of avoiding the corrections due to different coefficients of expansion when the measurements are not performed at the standard temperature determined on the adoption of a steel having a carbon content of 1.00 to 1.25 per cent (the regular tool-steel carbon content) and from 1.00 to 1.50 per cent of chromium to prevent corrosion.

The various operations required for finishing the gages are as follows:

Number of Operation	Description of Operation	Number of Operation	Description of Operation
1	Stock	9	Finish grind radius on edges
2	Turn, drill, ream, countersink one side, cut off	10	Rough lap
3	Rough grind the cut-off side	11	Inspect
		12	Lap countersink, both sides
4	Countersink the cut-off side	13	Finish outside diameter
		14	Finish lap faces
5	Mark size	15	Final inspection and measurement
6	Heat treat		
7	Rough grind faces	16	Assemble in sets
8	Season	17	Pack and ship

In the hardening operation, No. 6, the gages are preheated slowly to a temperature of from 800 to 1000 deg. fahr. They are then placed in a lead pot and heated to from 1550 to 1569 deg. fahr. It is said that quenching from this temperature into water through oil results in gages which have a hardness ranging from 90 to 95 scleroscope scale, and the number of cracked gages is reduced to a minimum.

In operation No. 8 the gages are given a seasoning treatment which consists of immersing them alternately in boiling and ice water about 30 times and holding them there just long enough to attain the temperature of the liquid.

The finish-lapping of the gages, operation No. 14, is done on the Hoke lapping machine. In this device the work is done on a lapping fixture driven by a vertical drilling machine and consisting of three plates; the lower and upper plates are lapping plates and are secured against rotation; the intermediate plate, which is the gage-block carrier, rotates and oscillates at the same time. The thickness of the blocks is equalized by transposing them diametrically and at 90 deg. at various times during the process of lapping. Another machine for lapping precision blocks is described and illustrated in *American Machinist*, March 27, p. 613.

The final inspection listed under operation No. 15 is made in the optical laboratory with the use of the light-wave interference method. The apparatus employed includes only two optical glass flats and a source of light. The process consists of wringing two glass plates on each end of the gage and determining with suitable apparatus the number of light waves between the gage planes. Inasmuch as the exact number of light waves in a length represented by the international standard meter has been determined to within an accuracy of about one part in 15 million, the length of a light wave is very definitely known and is constant. Therefore the determination of a number of light waves between the two glass planes on each end of the gage is equivalent to determining the exact length to a high degree of accuracy. The use of a source of light of one color, such as helium or a mercury-vapor lamp is not absolutely necessary, but in this case the interference bands take the form of more definite light and dark spaces, and thus the inspection is facilitated; with daylight the interference bands are made up of several colors merging into one another. The entire process of comparing gages by the light-interference method is extremely simple, and the cost of the measurement and inspection, including the determination of the standard for each size gage, is in the neighborhood of seven cents per gage.

University Teaches Naval Architecture

The University of Michigan announces the introduction of an intensive training course in Naval Architecture into its curriculum. The course begins January 6, 1919, and will run for eleven weeks.

The announcement states that applicants to be enrolled should be graduates of civil, mechanical, electrical, mining or architectural engineering courses, or should have the equivalent of such training. Men who have completed their junior year in college in any of those engineering courses will be given consideration as applicants. The tuition is $32.25 for the course payable to the University, each student to pay his own expenses. Prof. E. M. Bragg is at the head of the course, which is designated the Department of Naval Architecture.

The Education and Training Section of the Emergency Fleet Corporation is coöperating with the University to make the course a success. While it does not guarantee the employment of men by shipbuilding companies, and will not employ such men itself on completion of the work, the Section will assist in obtaining work for men who finish the course successfully and who may be recommended by the Department. (*Emergency Fleet News*, Dec. 5, 1918, p. 5)

Interesting Figures on Munitions Production

An advance summary of certain features of the forthcoming report of the Secretary of War as Director of Munitions, was published in the New York *Times*, April 6, 1919. This summary was prepared by Col. James L. Walsh and contained the following data of engineering interest.

Before the United States entered the war a total of 50 machine

guns was the standard equipment of an infantry division. When the armistice was signed the total machine-gun equipment of a division consisted of 768 light automatic and 262 heavy machine guns—an increase of 2060 per cent.

Of shoulder rifles there were produced in the 19 months of our participation in the war over 2,500,000—France produced only 1,400,000 and England 1,970,000. Of small-arms ammunition for pistols, rifles and machine guns 2,879,148,000 rounds were produced between April 6, 1917, and November 11, 1918, a total of one complete round every 20 seconds for 1918 years. Of machine guns and automatic rifles, America produced a total (181,662) slightly greater than that of England (181,404), and slightly less than that of France (229,238); but a fairer basis of comparison—the average monthly rate of production—indicates that America was producing 27,270 per month, more than twice as many automatic rifles and machine guns per month as France (12,122), and nearly three times as many per month as England (10,947).

As to artillery ammunition, a typical instance is the 75-mm. project. Of this caliber four and a quarter million of high-explosive shells, more than a half million of gas shells and over seven and a quarter million of shrapnel had been produced complete when the armistice was signed. From January 18, 1918, when the first complete American division entered the line, until firing ceased on November 11, 1918, a total of six and a quarter million rounds of 75-mm. ammunition were expended by American artillerymen.

Efficiency the Keynote in Shipbuilding

Holden A. Evans, president of the Baltimore Dry Docks and Ship Building Company, spoke recently on the question. What is to be done to make possible the continuance of shipbuilding in this country? His answer is that only through the removal of the various inefficiencies that now exist in the industry and by the education and training of workmen can this be done.

Before the war cargo ships were built in Great Britain at from $30 to $40 per deadweight ton. At the same time, some cargo ships of similar type were built in this country at from $60 to $70 per deadweight ton. Today contracts are being placed in Great Britain at $100 to $120 per deadweight ton. In this country, under present conditions, it will cost the shipbuilder from $170 to $180 a ton to build the same ship.

Wage schedules are today double what they were before the war and steel plates which could then be bought at $1.10 have risen as high as $3.25. The high cost of construction is obviously due in part to the increase in labor and materials; but principally, Mr. Evans contends, to *inefficiency*, which he classes under the following heads:

The inefficiency of a large number of unskilled men taken in the yards, due to the enormous plant expansion.

Inefficiency due to rush war methods. Speed of construction has been the only thought, which brought about extravagant methods. Old trained men are not as efficient today as they were before the war. It will take some time to bring them back to normal efficient methods.

The inefficiency due to the rapid increase in wages. The men do not work as steadily as before the war. There is much more lost time.

He adds: "The American people are thoroughly convinced of the absolute necessity of our own merchant marine, and we are going to have it. But if we are to maintain a great American-built, American-operated merchant marine, the American people must in some way or another pay for the excess cost while we are learning to build and learning to operate. In no other way will we ever get it."

NATIONAL RESEARCH COUNCIL

THE National Research Council of the National Academy of Sciences, which has been one of the potent factors in the development of scientific and research problems during the war, has now been organized on a permanent basis in order to promote research in the mathematical, physical and biological sciences and in the application of these sciences to engineering, agriculture, medicine and other useful arts.

Throughout the period of our participation in the war the National Research Council conducted a very large and successful work, largely through the foresight and active direction of its distinguished chairman, Dr. George E. Hale, director of Mt. Wilson Observatory. Doctor Hale had previously been in Europe investigating research matters and brought to the Council an intimate knowledge of accomplishments in other countries and of the requirements which the Allies of the United States had found necessary to meet in the research field. It is hoped that the Council may long have the continued service of Doctor Hale in his capacity as chairman whereby he has contributed so much of his enthusiasm and scientific knowledge to the advancement of science and the arts in America.

In this connection, it is interesting to note that the National Academy was organized at the request of President Lincoln to meet the scientific needs of the country during the Civil War; and likewise the Research Council came into existence by an executive order of President Wilson to extend the work of the Academy into a broader field of research during the recent war.

The permanent organization of the National Research Council replaces the temporary organization under which it has heretofore operated, and its membership is to be chosen with a view to forming an effective federation of the principal research agencies in the United States concerned with the field of science and technology. It is to consist of

(1) Representatives of national, scientific and technical societies.

(2) Representatives of the Government, as members and provided in the executive order.

(3) Representatives of other research organizations and other persons whose aid may advance the objects of the Council.

Organization of National Research Council

The Council is to be organized in two divisions,—one of General Relations dealing with foreign and states relations, educational relations, industrial relations, etc.; and the other of Science and Technology. The latter will include divisions of physical sciences, engineering, chemistry and chemical technology, geology and geography, medical sciences, biology and agriculture, and anthropology and psychology.

To secure the effective federation of the principal research agencies in the United States, a majority of the members of each of the divisions of science and technology are to consist of representatives of scientific and technical societies. The other members are to be nominated by the executive committee of the division, approved by the executive board of the Council, and appointed by the president of the National Academy.

The affairs of the Council are to be administered by an executive board of which the officers of the Council, the president and the home secretary of the National Academy of Sciences, the president of the American Association for the Advancement of Science, the chairman and vice-chairman of the Divisions of Science and Technology, and the chairman of the Divisions of General Relations shall be ex-officio members.

National Research Fellowships

The very large way in which the Research Council is functioning is indicated by the recent support accorded to it by the Rockefeller Foundation through an appropriation of $500,000 to be expended within a period of five years for promoting fundamental research in physics and chemistry, primarily in educational institutions of the United States. The primary feature of the plan is the initiation and maintenance of a system of National Research fellowships to be awarded by the National Research Council to persons who have demonstrated a high order of ability in research for the purpose of enabling them to conduct investigations at educational institutions which make adequate provision for effective prosecution of research in physics or chemistry. It is expected that 15 to 20 research fellow-

ships will be available during the coming year and that the number will be increased in subsequent years. The Research Fellows will be permitted to conduct their investigations at institutions that will coöperate in meeting their need and that are amply supplied with equipment, and above all, that are conducted in the stimulating atmosphere to be found only in institutions that have brought together groups of men devoted to the advancement of science through the pursuit of research.

Applications for these fellowships should be made on the form provided for the purpose and should be sent to the secretary of the Research Fellowship Board, National Research Council, 1023 16th Street, Washington, D. C.

Representatives Abroad

Two distinguished representatives of the National Research Council have recently left for Europe on important commissions. Dr. Charles S. Howe, president of Case School of Applied Science, sailed for France on April 19, where he will assume the duties of scientific attaché to the United States Embassy in Paris. This appointment is regarded as a notable development in the American diplomatic service produced by the war and the appointment will be watched with interest, as it is expected the industries of the country will be materially assisted by authentic information on the scientific discoveries which may be made in Europe. Dr. Comfort A. Adams sailed for England on April 14, and later he will go to France to attend the conference of the International Electro-Technical Commission to be held in Paris.

ENGINEERING DELEGATES REPORT TO FRENCH CONGRESS

The American delegation of Engineers who recently went abroad to investigate reconstruction problems, rendered a preliminary report to the Congres General du Genie Civil previous to returning to this country. A summary of this report was recently presented to the Council of The American Society of Mechanical Engineers by Mr. Charles T. Main, Past-President of the Society and its representative on the delegation. The following abstract brings out some of the most interesting features of the report.

THERE is but one national engineering society in France, the Société des Ingénieurs Civils, which includes engineers of all branches of the profession. It was not unnatural, therefore, that when the invitation was sent to the American engineers that it should have been addressed to the American Society of Civil Engineers. Nearly all of the problems submitted to the American Delegation were problems in civil engineering, and only incidentally those which might be classed under the headings of mechanical, electrical or mining engineering.

At the time of their appointment the delegates were of the impression that the problems which were to be discussed with the French engineers were those concerning the reconstruction of devastated areas. It soon developed, however, that this was not the case, and that the problems to be considered werę of a much broader scope, and those which would profoundly affect the future policy of the development of the Republic. While these problems were of broad interest and great importance, they were nevertheless not so definite and of such immediate interest as would have been those dealing directly with the subject of reconstruction.

Ports and Inland Waterways

Among the recommendations made to the French engineers were a number relating to the development of ports and inland waterways. The desirability of concentrating on the improvement of a few principal ports rather than scattering efforts over many large and smaller ones, was pointed out, and the use of modern freight-handling apparatus and close connection between railroad tracks and wharves to reduce the time of vessels spent in port, strongly urged. A more limited use of enclosed basins with locks was also suggested, and the advantages of wharves with suitable loading and unloading apparatus, and a sufficient number of dry docks and facilities for repairs, were enumerated.

The Delegation also recommended that financial accounts and statistics relating to each port should be kept separate from those of other ports, so that the relative efficiency should be determined.

Water Power

The Delegation did not feel inclined to discuss the laws relating to water power, as they were too complicated, but it did recommend that no project should be undertaken unless it could be demonstrated to be economically justified. The Government, it suggested, should encourage these enterprises and render financial aid, temporarily or permanently, in view of collateral advantages.

The necessity of standardizing the characteristics of their electric systems and the possibility of making one great connected system for the entire country was discussed, and recommendations of 50 cycles for local distribution and 25 cycles for long distance were made for careful consideration.

The Delegation also recommended that effective measures be taken to facilitate the extension of existing installations and construction of new ones where such extensions or new construction are justified. France has within her borders, in three rather widely separated regions, water-power possibilities which are probably sufficient, if developed and utilized, to obviate the necessity now existing of importing coal for power purposes. The importance and desirability of a unified system is emphasized by the study of the seasonal characteristics of the flow of the streams in the different regions. The low-water flows in these several regions do not occur simultaneously and thus combined operation will make it possible to utilize a greater amount of continuous power than could be utilized if the various groups of plants were operated independently. No insurmountable technical difficulties stand in the way of operation of such a unified system, and while the data for an exact study of the cost and results of interconnecting the several regions were not at hand, a general consideration of the situation led to the opinion that it would be amply justified. It was recommended that steam plants be connected to the general distributing system and operated in such a way as to supplement the varying amount of power which can be derived from hydraulic sources. The concentration of electric power production by steam in a small number of large, modern plants will result in a great economy of coal as compared to the amount required to produce equivalent power in a large number of small steam plants; and at high potential, such as is now in successful use in America, electric energy can be transmitted for much less than the cost of transporting the coal required to produce the same amount of energy. The use of auxiliary steam power developed in large plants properly interconnected with hydroelectric plants can be utilized advantageously in supplementary power from the latter at certain seasons of the year.

Navigable Waterways

With a few special exceptions, the experience with works of inland navigation in the United States has been disastrous. In France, however, the conditions are more favorable. The Government there has assumed the payment of interest on works of internal navigation, and also expenses of maintenance.

The four purposes of control of a river are the development of power, irrigation and domestic water supply, improvement of navigation, and regulation of floods, and these should always be considered together. No project should be undertaken which will not be economically justified when all uses are considered and all charges included.

Roads

In the past the French used broken stone for their highways, but such construction is now unsuited to the traffic. The Delegation accordingly advised the use of cement concrete, bituminous and brick coatings, the preference depending on climate, travel

and cost. Brick coatings can be used in exceptional cases only: cement roads only where materials are at hand at a low price.

On account of the enormous destruction of roads during the war, considerable reconstruction is necessary, but it has been found that in most cases the existing foundations can be used. Under the present laws bonds cannot be issued for this work, but it is necessary to have appropriations made by the various territorial departments or by the communes. Some arrangements, it was suggested, might be made with private enterprises for constructing and maintaining the roads.

Agriculture

The rehabilitation and expansion of agriculture should be based on improved financial facilities, which require modifications in the banking laws of France. To this end the delegation recommended that working capital for farmers should be obtained from the sale of long-term farm bonds. It also recommended safe and convenient procedures for establishing chattel mortgages; a comprehensive system of warehouse receipts, bills of shipment or lading, acceptances of commission houses, etc., so that records of property may be accepted as collateral; and amendments to banking laws to permit loans for a period in a year or more.

The establishment of modern slaughterhouses and cold-storage plants and refrigerator cars was also urged, although this also will require modification of laws to establish effective sanitary supervision. Persistent campaigns toward better hygienic conditions among the farmers were advocated, as well as rural welfare movements to increase the comforts of farm life.

Technical Education

Many papers dealing with technical education were presented to the Congress. The question was very complex, reaching from the lowest primary to the highest technical education. However, it was recommended that agricultural schools be established; also courses in chemistry and chemical engineering; and that the field and scope of engineering should be brought to the attention of students in the secondary schools, and schools should be provided to receive all young men who are qualified and desire to pursue technical studies.

The interchange of students, professors and instructors between France and America was held to be eminently desirable, but all agreed that France must offer greater encouragement than formerly if she instead of Germany is to be the place for post-graduate work.

Franco-American Engineering Committee

Pending the completion of its formal report, the Delegation of American Engineers has submitted to the national societies which it represents the following statement:

The French Congres Général du Génie Civil, at its meeting on January 15, 1919, adopted the following resolution:

"In order to study both the possibilities and the means of coöperation which have been considered between the engineering societies represented by the members of the American Delegation and the representatives of the French Civil Engineers, it would be highly desirable to maintain the contact which has just been established.

"For this purpose the formation of a permanent Franco-American Committee should be the first result of the studies and trip of inspection which has just taken place.

"The American Delegation and the delegates of the Génie Civil unite in expressing a resolution in favor of the immediate formation of this permanent International Committee."

The members of the American Delegation were requested by the French engineers to act as the American members of the Permanent International Committee. This, however, the delegation declined to do, explaining that it represented the four national engineering societies of America, to which societies it must report, and in whose hands any permanent action must lie.

However, to meet the desire of the French engineers for the immediate creation of an International Committee, and in view of the fact that the Delegation still has some work to do in preparing reports and information for transmission to the French Committee, the members of the Delegation consented to act temporarily as the American members of the International Committee, promising to bring the matter to the immediate attention of the societies they represent, and to secure immediate action if possible. Accordingly, the American Delegation, at a meeting held January 25, 1919, unanimously passed the following resolution:

Resolved: That the Delegation bring to the immediate attention of the national societies which they represent the facts with reference to the formation of a permanent Franco-American Engineering Committee, and urge upon the societies that they take immediate action to constitute the American representatives upon such a Committee.

ELECTRICAL MEASUREMENT OF FLUID FLOW IN PIPES

(*Continued from page 432*)

constant by varying the field of the generator supplying the power, thus approximating the actual condition of an average installation. The secondary voltage varied due to the transformer regulation, but the resistance element of the instrument is designed to compensate for such regulation, so that the indicated variations of current gave a fairly accurate measurement of the differential pressure.

Conclusion

The fact that the flow of fluids can be measured electrically has made possible many important installations where no other method could be employed. In one instance a large manufacturing concern had been contemplating for a long time the adoption of a system for measuring the amount of steam, air and water used by its various departments, but was hindered by the fact that the various lines were distributed over a wide area and in some places were carried through sub-basements, where measuring devices would be inaccessible; also much time and a large force of employees would be required to read the various instruments about the plant and to integrate the recording charts. As soon as the concern discovered that flow could be measured electrically, that the indicating instruments did not have to be located where the flow was to be measured, and that the integrating device was merely a watt-hour meter which integrated the flow independently of the other instruments, a measuring system was instituted for all its products and many wasteful uses of power were thereby eliminated and an accurate distribution of costs established throughout the factory.

The adaptability of the integrating feature to the electrical measurement of flow is of great importance since the readings from the watt-hour meter are more accurate than those taken from the recording ammeter and just as accurate as the instantaneous readings of the indicator. This feature therefore eliminates the necessity of planimetering the charts and insures accurate results for any variation of flow.

When measuring the flow of steam generated by a battery of boilers the flow indicators are placed in front of each boiler, showing the momentary performance for the guidance of the fireman. At the same time, supplementary recorders connected electrically with the indicators are placed conveniently for the supervision of the chief operator.

Recently the manufacturers of water gas adopted the use of low-pressure exhaust steam for gas generation, which created an urgent demand for a measuring device to operate intermittently, varying every few minutes from zero to maximum. After many unsatisfactory trials of mechanical devices the electrical method of flow measurement was adopted, as this made it possible to measure successfully the steam required for the manufacture of water gas and resulted in a great economy.

The main advantage, however, of the electrical method of flow measurement is the accuracy with which the differential pressure is transmitted through a mercury column, which column is not hindered in its movements by any mechanism and is therefore free to attain the true level under all conditions of flow. Furthermore, the electrical instruments used to register the flow can be checked at any time without interfering with the operation or installation of the measuring device.

ENGINEERING COUNCIL

Engineering Council[1] is an Organization of National Technical Societies of America, Created to Consider Matters of Common Concern to Engineers, as Well as Those of Public Welfare in Which the Profession is Interested

Classification and Compensation of Engineers

THE make-up of the Committee on Classification and Compensation of Engineers has been completed. It comprises a main committee and three sub-committees or sections, as follows: *Main Committee:* Arthur S. Tuttle, *Chairman;* Francis Lee Stuart, John C. Hoyt, Charles Whiting Baker, M. O. Leighton. *Railroad Section:* Francis Lee Stuart, *Chairman;* Frank H. Clark, Bion J. Arnold. *Federal Government Section:* John C. Hoyt, *Chairman;* John S. Conway, Oscar C. Merrill. *Municipal* (including City, County and State): Arthur S. Tuttle, *Chairman;* M. M. O'Shaughnessy, F. W. Cappelew. The Railroad Section has been the first to get into action, its chairman, Mr. Stuart, having appeared before the Railroad Administration's Board as reported below.

Hearing on Classification and Compensation of Railroad Engineers

AT a recent hearing by the Railroad Administration's Board on Wages and Working Conditions, arguments were presented by representatives of Engineering Council, appearing for the Societies of Civil, Mining, Mechanical and Electrical Engineers, and the Society for Testing Materials; and representatives of the American Association of Engineers.

Francis Lee Stuart opened the hearing for Engineering Council, which, he said, had been advised (1) that engineers and engineering assistants of the more important classes on the railroads have been individually considered as belonging to the Officer or Supervisory Force, and certain increases of salary have been granted them by the Railroad Administration; (2) that whereas the men in subordinate positions in the civil, mechanical, electrical and signal departments have also been granted certain increases, they have not been given a classification such as the Supervisory Force has had.

He urged that it would be for the best interest both for the social and economic welfare of the railroad professional engineers of the United States that the case of these younger engineers holding subordinate positions be further considered. Before the war the compensation of these engineers was notably inadequate and the increases which have been granted the men in the subordinate positions do not seem to them sufficient. Engineering Council, through this committee, asks that the employees of the engineering departments—civil, mechanical, electrical and signal, who were not considered in the Officer or Supervisory Force, but who will, from their technical education or training, at some later date occupy the higher positions in these departments, be given a classification and the titles of these positions standardized, and a proper remuneration be given them in order that their physical welfare and mental interest may be provided for so as to insure efficient service to the public.

Mr. C. E. Drayer appeared first for the American Association of Engineers and offered a wage schedule for subordinate engineers which had been approved by Railroad Engineers' Convention, in Chicago, on March 17, 1919.

Mr. W. C. Bolin then said it had been estimated that the education required to fill an average railway engineer's place represented a capital of \$10,000. At the present scale of wages, he declared it impossible for the engineer, except under unusual circumstances, to recover his \$10,000 investment in education. The apprentice in the mechanical department is better off than the boy who enters school to take an engineering course. The apprentice earns money while the other boy is spending money for education, and under the existing rate scale, the former would continue to get more money throughout his career.

The full Board was present at the hearing and manifested unusual interest in the entire proceedings. It is believed that substantial increases in salaries for the junior technical engineers on railroad work are in sight and will very probably be a reality as soon as the Board can get the additional data and information required to complete its work.

NATIONAL SERVICE COMMITTEE

Engineering Legislation in the Past Congress and in Prospect

ALL engineers should understand that legislative measures in which they are most concerned do not succeed in Congress merely by reason of merit. Such bills fail to become laws, not because of adverse votes on the merits, but because of no votes. Congress is deluged with bills. In the Sixty-fifth Congress there were over 16,000 separate and distinct measures introduced into the House, and nearly 6000 into the Senate. These, together with hundreds of joint resolutions, made up a legislative program which could not possibly be digested or appraised according to merit. The Sixty-fifth Congress does not differ from preceding Congresses in this respect, nor will it differ from future ones. Under such conditions the legislation must be the result of interested work by persistent advocates.

Engineering legislation usually fails because there are no engineers in Congress to become its champions. We fail to recall a single worthy engineering measure in the past decade that did not have voting support enough to carry it through; but this was passive support—it did not contrive an opportunity to vote. The good lawyers, farmers, journalists and business men who make up the Congress have to become engineering students when they champion an engineering measure. They have to learn fundamental principles, facts and figures, all in an unfamiliar field. These men are already too busy with subjects with which they are already familiar. Here and there men are found willing to put aside the subjects familiar to them and take up engineering matters. Of course, they merely touch the high spots, and, in common with all high-spotters, they usually "fall down hard" when they get into action.

The members of Congress are not to blame. They deserve profound thanks for their efforts and accomplishments. If any engineer doubts this, let him for the moment assume that he is a member of Congress and is suddenly called upon to familiarize himself with and champion a measure based on international law or preventive medicine. Would he perform better than the lawyer does in Congress on engineering matters? Manifestly not. Therefore let us be persuaded that so long as engineers shirk participation in legislation and remain unrepresented in Congress, just so long must their legislative measures be conducted through the parliamentary maze, not by blood relatives, but by well-meaning foster parents.

To appreciate the truth of this, one needs merely to review the proceedings of the Sixty-fifth Congress. Some of the big engineering measures arrived at the point of final vote at the eleventh hour, were caught in the jam of filibuster, and died. The Water Power Bill, for example, had been on the road for several years, and a determined push by engineer members would have undoubtedly carried it through the Sixty-fifth Congress with months to spare.

An apparent exception to these general conclusions is the case of the engineering measure for the appropriation for public highways. This bill did pass, but as a rider on the Post Office appro-

[1] Officers of Engineering Council: J. Park Channing, *Chairman;* Alfred D. Flinn, *Secretary,* Engineering Societies Building, 29 West 39th Street, New York.

Washington Office in charge of M. O. Leighton, *Secretary,* National Service Committee, McLachlen Building, 10th and G Streets.

Representatives of The American Society of Mechanical Engineers on Engineering Council: Ira N. Hollis, Charles Whiting Baker, George J. Foran, Mortimer E. Cooley, David S. Jacobus.

priation bill. It was a measure easily understood, and one in which members of Congress were personally interested, and it was practically inevitable that it would be passed.

Mineral Resources

Another bill that failed in the last Congress—that was talked to death—was the long-discussed measure for opening up the mineral resources of the public lands for development. The point to be impressed in this connection is that it is possible by strict adherence to parliamentary rules and practices for one "willful man," by means of filibustering tactics, to deny for the time being an otherwise unanimous demand. It is expected that this bill will be introduced in the next Congress, where it is hoped it will be regarded in the nature of unfinished business and thus receive early consideration and passage.

The Water Power Bill

The fate of this bill was the same as that of the Mineral Lands Bill above mentioned. For at least six years the differences of opinion which have prevented the people of this country from enjoying the economic advantages of water-power development on the navigable streams and on streams in the public lands have related to matters of minor importance from the purely development standpoint. One great bone of contention has been the matter of charge or annual payment to the Federal Government for the privilege of developing water powers. This has been of only the remotest interest to public-utility companies and to investors because the charge imposed by the Federal Government must of necessity be paid by the consumer. Nevertheless, this and other points of similar purport have brought water-power development to a virtual standstill in all situations in which the Federal Government has jurisdiction. These difficulties have at last been ironed out, and the bill will again come up in the Sixty-sixth Congress.

Good Roads Legislation

Relatively few engineers have done more than to glean from the press a general idea that the Government is embarked on a road-making policy. Yet the subject is one which demands the thought of every engineer. It is the biggest and most costly internal improvement program ever known in our history. The Federal Road Act, approved July 11, 1916, provides for an appropriation of $75,000,000 during a period of five years, allotments from which, however, are to be made only as the states add equal amounts.

Further, the Post Office appropriation bill passed by the last Congress increased the statutory limit of unit cost of highways built under its provisions from $10,000 to $20,000 per mile, and appropriated in addition to the sums above mentioned a further sum of $50,000,000 for the fiscal year ending June 30, 1919, and $75,000,000 for each of the two following fiscal years. Thus we have a total of Federal and State moneys available to June 30, 1921, of $550,000,000, to which may be added an additional $10,000,000 appropriated by Congress for roads and trails in the National Forest.

The Soldiers' Land Settlement Bill

A bill of particular interest to engineers and yet one which the Congress also failed to pass is the Soldiers' Land Settlement Plan. Under this bill returned soldiers, sailors and marines would be employed on construction work in the reclamation of swamps and arid lands, and would thereafter be given preference in the selection and settlement of those lands. A new bill has now been written for introduction at the next session which, however, instead of providing for the development of new tracts, proposes an "infiltration method" of buying improved farms in established communities. The contrast of this bill to the one recommended is of vital importance to engineers, chiefly because of the broad engineering program that the latter bill proposes as against no engineering under the infiltration method.

Those who favor the new bill argue that it will cost less than the community plan; also that a greater increase in production of food would be secured from the intensive cultivation secured thereby. On the other hand, those who favor the community plan argue that the infiltration plan is impracticable because it will not eliminate the lag of cultivated area behind our increase of population. In the ten-year period subsequent to 1900, our cultivated area increased only about one-half as fast as did the population.

It is interesting to note in this connection that the infiltration and the community plans have both been tried in Australia. The latter proved a success, whereas the former was a failure. After long and careful study, Great Britain also adopted the community plan and we have come to the conclusion that the community settlement plan is best fitted to our requirements.

War Minerals Claim

One of the most important matters now under consideration at Washington is the determination of the remuneration to producers of manganese, chrome, pyrites and tungsten, who in their efforts to meet Government requirements during the war met with heavy losses. Congress has passed a bill setting aside $8,500,000 to meet such claims, and the Secretary of the Interior has been given authority to expend this sum following proper proof of claims from the producers affected.

To assist in this important work, Secretary Lane has appointed a Commission to gather and settle these claims. The work has progressed rapidly for such matters, as a test case was heard in Washington, D. C., on April 15. The claim involved the Charles T. Pyrites and Chemical Co.

At this hearing the interested company was permitted to retain counsel, and it is therefore contemplated that other claims will be permitted to do so, although it has been pointed out by the Commission that claims without attorneys will have every opportunity to get all the facts before the Commission.

Topographic Mapping

If the topographic survey of the country does not proceed more rapidly than prescribed by Congress in the past, a generation at least will have past before the work is completed. Accordingly, Engineering Council has urged the Secretary of the Interior that he recommend to the 66th Congress the importance of increasing the appropriation for that work from $350,000 to $500,000. The importance of topographic mapping hardly needs to be urged or explained to the engineering profession.

In the execution of our national road-construction program, in water-power development, in the fields of mining and geology, in the extension of railway systems, etc., a complete topographic map of the sections involved is a fundamental necessity and becomes the greatest single aid, time saver and means of economy that can be placed in the hands of the constructors.

Proposed Pan-American Conference

A Pan-American Industrial Conference fully as pretentious as was the Pan-American Scientific Congress held in 1915 is under consideration by the Pan-American Union. It is considered practically certain that such a conference will be held. American engineering has taken such an important place in Latin America that it will occupy a prominent place on the program. This will be the first conference of the kind which will be devoted exclusively to the economic features of Pan-American relationships.

Open competitive examinations are now being advertised in the New York City Record for positions in the city employ. These include Mechanical Draftsman Grades C ($1200 to $1800 per annum) and D ($1800 to $2400) for Heating and Ventilating and Electrical Draftsmen. Those desiring to take examinations should apply on or before May 7, 1919, for the proper application blanks, addressing the Municipal Civil Service Commission, 14th story, Municipal Building, New York.

NEWS OF THE ENGINEERING SOCIETIES

Reports of Annual Meetings of Mining and Electrical Engineers and Electric Railway Association —The Aims of an Engineering Society, etc.

Newly Formed American Petroleum Institute

Government officials having to do with matters pertaining to the petroleum industry are very anxious that the newly formed American Petroleum Institute establish its headquarters in Washington. With few exceptions, the important industries of the country are represented in Washington by organizations which are prepared to give immediate information concerning any phase of their activities, and committees of Congress are coming more and more to rely on these national organizations for information.

Electric Furnace Association

On the afternoon of April 3 the recently formed Electric Furnace Association held a meeting at the Chemists' Club, New York. A tentative draft of the constitution and by-laws was adopted pending such time as is necessary to secure a representative list of members from the various industries interested in the work of the association. An aggressive campaign will be undertaken at once to secure members from manufacturers of electric furnaces, electric-furnace supplies, electric-furnace products, etc. This was the second meeting of the association, which is another instance of the present tendency of manufacturers in a given line to get together for their mutual good.

Engineering Society of Western Massachusetts

A dinner and organization meeting of the Engineering Society of Western Massachusetts was held at the Hotel Kimball, Springfield, Mass., on Wednesday evening, April 16. The following officers were elected: Charles L. Newcomb, president; C. C. Chesney, vice-president; George E. Williamson, vice-president, and Winfield E. Holmes, secretary and treasurer.

The constitution and by-laws provide for four grades of members, an entrance fee of five dollars and annual dues of the same amount.

The speakers included Prof. L. P. Breckenridge, Mr. William Spencer Murray, and Dr. George Otis Smith. Over 300 persons attended the dinner and nearly 1100 applications for membership were presented.

American Welding Society

The newly-organized American Welding Society held its first meeting in the Engineering Societies' Building, 29 West 39th Street, New York, on March 28. This is an outgrowth of the Welding Committee organized by the Emergency Fleet Corporation and the Council of National Defense to develop welding methods and coördinate the welding industries during the war. The constitution and by-laws were adopted as recommended, and it was also voted to consider all those who apply for membership before April 8 as charter members of the society. Announcement was also made of the election of Comfort A. Adams as president and the appointment of W. E. Symons as treasurer and H. C. Forbes as secretary.

The first honorary member of the society is Prof. Elihu Thomson, who was characterized by President Adams as the father of electrical engineering in this country.

The main offices of the society are located at 29 West 39th Street, New York City.

Meeting of the American Chemical Society

The American Chemical Society held its spring semi-annual meeting on April 7-11 in Buffalo, N. Y. The convention was named the "Victory Meeting" in view of the new industries which the chemists of this country built during the time of the war.

The papers and discussions presented formed a complete index to American progress in the chemical arts. A few of the topics treated in the session of Industrial and Engineering Chemistry were: Corrosion Tests on Commercial Calcium Chloride Used in Automobile Anti-Freeze Solutions, by Paul Rudnick; Non-Metallic Inclusions in Steel, by E. G. Mahin; Mineral Rubber, by Gustav Egloff; and Testing Materials for Increasing the Water Resistance of Sole Leather, by H. P. Holman and F. P. Veitch. A symposium on Library Service in Industrial Laboratories was another feature of this session. Other divisional meetings dealt with the physical and inorganic, biological, organic, and pharmaceutical applications of industrial chemistry.

New Cuban Engineering Society

There was established in Havana on the evening of February 21 the Association of Members of American National Engineering Societies in Cuba. This organization restricts its membership to persons who are members of the following American national engineering societies: The American Society of Mechanical Engineers, the American Society of Civil Engineers, the American Institute of Electrical Engineers, the American Institute of Chemical Engineers, the American Society of Agricultural Engineers, the American Society of Refrigerating Engineers, the American Institute of Mining and Metallurgical Engineers, the American Institute of Architects, the American Iron and Steel Institute, and the American Chemical Society.

There will be four regular meetings each year, one of which will be the Annual Meeting, occurring on the second Friday of December. The headquarters of the Society are located at No. 17 Empedrado, Havana.

The officers for the coming year are Luther Wagoner, president; George H. Nolan, vice-president; T. Carlile Ulbricht, secretary, and Wallace R. Lee, treasurer.

American Electrochemical Society

The best-attended meetings in the history of the American Electrochemical Society were held at the Chemists' Club, New York, April 3, 4 and 5. Only two days were devoted to technical discussions, the chief topics being the products and possibilities of the electric furnace, and the work of the electrochemist during the war. Several papers were presented relative to the first of these subjects, the most timely perhaps being one by G. K. Elliott. In his paper on improving the Quality of Gray-Iron Castings by the Electric Furnace, Mr. Elliott outlined the most recent practice of employing the electric furnace in conjunction with the cupola in a foundry. Another paper of value was one on Electric Furnaces of the Resistance Type Used in the Production of Essential War Material, by T. F. Bailey, of the Electric Furnace Co., Alliance, Ohio. Following the presentation of Mr. Bailey's paper, moving pictures were shown of several of the installations described.

The Friday session was given over to papers dealing with the work of the electrochemists during the war. The use of silicon and titanium tetrachlorides in the manufacture of compounds employed in producing smoke screens was described by O. Hutchins and G. A. Richter. Compounds of these metals sprayed into moist air are broken up into silica and hydrochloric acid, and the latter in the presence of ammonia forms dense white

fumes of particularly effective screening value. Poison gases were also developed by the electrochemists and their work along these lines was described by Col. W. H. Walker, of the Chemical Warfare Service.

Government ownership of hydroelectric power developments was also discussed and a decided difference of opinion was found to exist. The report of a committee appointed to investigate this subject was made, and while a majority of its members favored private organization and operation, a report was also submitted by the minority members favoring Government control. When, however, both reports were put to vote, the Society decided in favor of private ownership.

The Society recently held its election of officers. The new President is Lieut.-Col. W. D. Bancroft, U. S. A., of the Chemical Warfare Service and professor of chemistry at Cornell University; the vice-presidents are D. U. Dorr, W. R. Whitney, and Dr. Carl Hering. B. G. Salow was reëlected treasurer and Dr. J. W. Richards again selected as secretary.

Dinner of Utah Section of A. I. M. E.

Over two hundred engineers sat down to the dinner of the Utah Section of the American Institute of Mining and Metallurgical Engineers, held at the Hotel Utah, Salt Lake City, on Monday evening, April 7. Homer V. Winchell, president of the A. I. M. E., Prof. C. K. Leith, Adviser at the Paris Peace Conference of Bernard Baruch, Prof. J. F. Kemp, Hon. Mem. A. I. M. E., and Hon. Reed Smoot, Senator from Utah, were the speakers. Calvin Rice, Secretary of the A. S. M. E., was present, together with a number of prominent engineers of the Society and also members of the Engineering Society of Utah who had previously attended an informal dinner at the University Club in honor of Mr. Rice.

The dinner of the Mining Engineers was a great success and the spirit of coöperation and get-together of all engineers of the locality strongly emphasized. Some glimpses of the tremendous part that the mineral industry plays in the affairs of the world, together with some intimations of the gigantic task before the peace conference, now adjusting the industrial and economic machinery of all nations, some expression of the responsibility that rests upon every American to do his part of the work that lies at hand, were vividly presented.

American Railway Engineers' Association

RECENT progress in rail manufacture and testing, as well as a new method of testing rail joints, was placed on record at the annual meeting of the American Railway Engineers' Association, held at Chicago during the week of March 16th. The proposed changes in the rail specifications are slight and yet exceedingly important, for they will call for a harder rail; establish a new acceptance standard, and create an entirely new form of test to be used in place of the familiar drop-test. The required percentage of manganese in open-hearth rail of all weights is raised by 0.10 per cent, making the limits read 0.70 to 1.00 per cent. For the heavy weights of open-hearth rail, 111 lb. per yd. and over, the required amount of carbon is raised by 0.05 per cent to the figures 0.67 to 0.80 per cent. A higher ductility is also demanded, the elongation in drop test being changed from 6 to 8 per cent. Acceptance is made more difficult by requiring that all three drop or bending tests representing a given heat must pass if the heat is to be accepted.

While the drop test has also been the final physical test for rails, the experience of the Pennsylvania Railroad has so clearly demonstrated the value of a bending test that it was adopted as an alternative to the drop test. The bend test is specified to be made with a 350-ton press on a 48-in. span, and autographic records of load and deflection are to be taken; the test is to be made preferably with the rail head in tension.

Rail-Joint Tests

As the result of many elaborate tests made by the Pennsylvania Railroad to determine the strength of rail joints, the Committee on Rails submitted and there were adopted new specifications for testing rail joints. These specifications demand that the test be made in a press, the rails being supported on two supports 48 in. apart and the load applied over the joint midway of the span. Measurements of deflection and set are to be made at 3000-lb. intervals of load, and from the results of the test the efficiency of the rail joint is to be computed as the ratio of the elastic limit of the rail joint to the elastic limit of the continuous rail. This efficiency is to be stated both for head up and for head down.

The Society of Industrial Engineers

THE Society of Industrial Engineers met in New York from March 18 to 21 and all who attended their conference were impressed with the fact that a new order of things is upon us. The future will see a greater service rendered by all, and not the least of the burden will fall upon the industrial engineer as he strives for a better understanding between capital and labor.

The session held on Tuesday evening was devoted to Manufacturing and Production Problems. Papers were presented by C. E. Knoeppel, president of C. E. Knoeppel & Co., Industrial Engineers; J. E. Otterson, vice-president of the Winchester Repeating Arms Co., and C. H. Scovell of Scovell, Wellington & Co. Dr. S. W. Stratton also spoke, and in discussing the work of the Bureau of Standards as related to commercial and industrial problems, illustrated his talk with stereopticon views.

The technical session on Wednesday evening was devoted to a consideration of labor problems. The speakers of the evening were Irving A. Berndt, Col. Walter Dill Scott, Magnus W. Alexander, Meyer Bloomfield and Dudley R. Kennedy. Colonel Scott discussed the personnel classification in the Army, and elsewhere in this issue will be found a paper describing in detail this important work.

Engineering Education

The afternoon session of Thursday was given over to a discussion of The Influence of Engineering Education. Dean Schneider, of the University of Cincinnati, was unable to be present and in his place Prof. D. S. Kimball of Cornell occupied the chair. The first speaker of the session was L. P. Alford, editor of *Industrial Management*. Mr. Alford discussed the engineer's place in reconstruction and pointed out that in our present complicated civilization, reconstruction must go beyond medieval ideas. We must do more, he said, than tell the people to "be good." We must show the worker the way and the means.

The chief of the training service of the Department of Labor, H. E. Miles, spoke on Training and Education of Workers. Over one-half the factory workers in the United States, he declared, are giving less than a half-day's fair production. This means a loss of approximately $170,000,000,000. Production, he insisted, must be increased and training is also needed. Mr. Miles also urged manufacturers to coöperate with the U. S. Training Service of the Department of Labor.

Executives as well as workers must be trained and educated, declared F. N. Steinmetz, Jr., president of the Western Efficiency Society. A danger, he said, rests in the possibility of industry continuing to be haphazard. The worker, the major executives and the minor executives must all be educated, and this, he believed, could best be done by the manufacturers themselves, coöperating with the various technical organizations.

The final address of the session was made by C. R. Dooley, on Standards of Engineering Education. As illustrating the work of the Government along these lines, he stated that of all the men who were drafted only 8 per cent had had a high-school education or better, and that the great majority had had no continuity of training. Furthermore, only one-half as many skilled men were found as were needed. The United States Training Service was given 90,000 men and in two months' time had graduated 7000 of them in approximately sixty different trades.

Industrial Engineering as a Profession

An informal banquet was held on Thursday evening, March 20. President L. W. Wallace presided and the topic of the evening was Industrial Education—The Profession. In discussing the subject Professor Kimball declared that the power of modern civilization rested upon the ability to produce worldly goods in enormous quantities. The capacity for production, he stated, was such that he could see no reason why we cannot feed the hungry and clothe the poor as no other people have ever done. People themselves are beginning to form convictions such as these and industry should be considered as the means of supporting human life in the best possible way, but this of course means a radical reorganization of industry if these ideas are to be carried out.

The Scope of Industrial Engineering was discussed by John R. Dunlap, and The Future of Industrial Engineering by Harrington Emerson, Director of Emerson Engineers, New York. Papers were also read by F. C. Schwedtman, vice-president of the National City Bank of New York, and Louis C. Marburg of Marburg Bros., Inc.

Labor-Saving Equipment

The final session was held on Friday afternoon, and the discussion was chiefly concerned with labor-saving equipment as related to maximum production and the elimination of fatigue. Mrs. Frank B. Gilbreth spoke on Fatigue Elimination, and referring to some recent studies by psychiatrists at Boston, emphasized the fact that their work had brought out the resemblance between patients coming to hospitals for psychopathic treatment and many employees in plants. There is, however, she declared, a marked difference between psychopathic fatigue and physical fatigue, and while a worker may not actually be fatigued in body, he may feel so mentally. Mrs. Gilbreth also declared that the psychologist had come into industry to stay and she urged a continuation of the admirable personnel work which had been accomplished by the Adjutant General's Department.

The Need for Labor-Saving Equipment was discussed by Leon I. Thomas, managing editor of *Factory*. About 25 per cent of the alien workmen in the Middle West, he said, are planning to return to their mother countries and such emigration may perhaps produce a shortage of common labor. Furthermore, a new social order is bound to arise and he predicted a great wave of education which, too, will decrease the supply of common labor. It is the duty therefore of the engineer to meet these needs.

J. M. Carmody, in discussing the industrial engineer and the future, considered that an open mind is of primary importance. Engineers, he declared, cannot afford to be behind in the new social order, and particularly industrial engineers, who have a vastly larger field than that of mere welfare work.

During the final session President Wallace announced that sections will shortly be formed at New York, Cleveland, Detroit and Chicago; and that the next conference will be held at Cleveland during the coming autumn.

For a portion of this report Mechanical Engineering is indebted to *The Iron Age*.

In its issue of March 21, *Engineering* (London) published an account of a meeting of the Diesel Engine Users' Association, and announced that, as a result of papers and discussion, the Association has approved and is now circulating among its members the following definitions of Diesel and semi-Diesel engines.

A Diesel engine is a prime mover actuated by the gases resulting from the combustion of a liquid or pulverized fuel injected in a fine state of subdivision into the engine cylinder at or about the conclusion of a compression stroke. The heat generated by the compression to a high temperature of air within the cylinder is the sole means of igniting the charge. The combustion of the charge proceeds at, or approximately at, constant pressure.

A semi-Diesel engine is a prime mover actuated by the gases resulting from the combustion of a hydrocarbon oil. A charge of oil is injected in the form of a spray into a combustion space open to the cylinder of the engine at or about the time of maximum compression in the cylinder. The heat derived from an uncooled portion of the combustion chamber, together with the heat generated by the compression of air to a moderate temperature, ignites the charge. The combustion of the charge takes place at, or approximately at, constant volume.

NECROLOGY

JAMES NISBET HAZLEHURST

Major James N. Hazlehurst, a prominent member of the engineering profession of Atlanta, Ga., died at Brussels, Belgium, February 9, 1919, at 55 years of age. Early in June, 1917 he was commissioned Major of Engineers and assigned to the staff of Major-General Wood, Commander of the Department of the Southeast, as water supply officer of that department. When in September of that year General Pershing cabled for 11 expert engineers, Major Hazlehurst was one of the number chosen to go overseas, serving as first assistant to the officer in charge of the water supply section for six months at General Headquarters, S. O. S., Toms. He was made water-supply officer for Base No. 6 in October, his territory extending from the Riviera to the Italian frontier. Late in January he was assigned to the American Commission to negotiate peace and as Director of the Division to estimate damage to buildings at Brussels, his death occurring while on this assignment.

He was author of a number of technical articles and also a book entitled Towers and Tanks. Major Hazlehurst was very active in technical affairs, taking a leading part in the organization of the Affiliated Technical Societies of Atlanta. He became a member of our Society in 1916.

JOSEPH W. HENDERSON

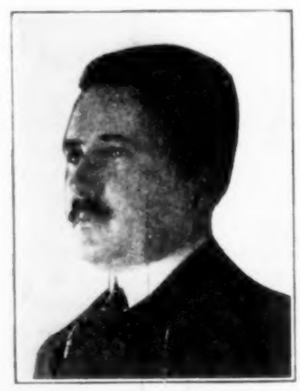
Joseph W. Henderson, chief of the Bureau of Smoke Regulation, Pittsburg, Pa., died on December 19, 1918. Mr. Henderson was born in Millbrook, Ontario, Canada, on February 22, 1869, and was educated in the schools of Jackson, Mich. He was formerly connected with the Griffin Wheel Co., Chicago, the Maryland Car Wheel works, Baltimore, and the Butler Car Wheel Co., Butler, Pa. He was also vice-president of the Gulick, Henderson Co., New York.

Mr. Henderson was a member of the American foundrymen's Association, the Railway Club of Pittsburg, and the Chamber of Commerce of Pittsburg. He became a member of the Society in 1916.

WILLIAM THOMAS COYLE

William T. Coyle, of the engineering department of the U. S. Naval Experimental Station, New London, Conn., died on December 18, 1918, of pneumonia.

Mr. Coyle was born in Hartford on January 11, 1887, and was educated in the public and high schools of that city. In 1905 he started work for the Sterling Blower Co., Hartford, as detailer, designer and draftsman on heating, ventilating and dust-carrying systems. From 1907 to 1909 he was connected with the Pope Manufacturing Co., Hartford, as draftsman. His next position was with the Dwight Slate Machine Co., also located in Hartford, as a designer of drill presses, gear cutters, marking machines, etc. In 1910 he became connected with the Bullard Machine Tool Co., Bridgeport, as a designer of boring mills, roughing lathes, etc.



William T. Coyle

After four years with this company he became special engineer for the Putnam Machine Co., Fitchburg, Mass., where his work dealt with the development of a new line of boring mills. From 1915 to 1917 he was with the Winchester Repeating Arms Co., New Haven, as designer of equipment and assistant chief draftsman, when he again returned to the Putnam Machine Co., until October, 1917. At that time he became associated with the Deane Machine Co., Fitchburg, as secretary and mechanical engineer. In the summer of 1918 he was called to the Naval Experimental Station.

Mr. Coyle became an associate-member of the Society in 1918.

FREDERICK LESTER LANE

Frederick L. Lane, works manager of the McCambridge Co., Philadelphia, died on March 6, 1919. Mr. Lane was born on March 6, 1856, in St. Johnsbury, Vt., and was educated in the schools of Springfield, Mass. He was formerly connected with the Chapman Valve Manufacturing Co., Springfield, as superintendent, and up to the early part of the present year held the position of mechanical superintendent with the Haines, Jones & Cadbury Co., Philadelphia. Mr. Lane became a member of the Society in 1915.

LOUIS H. MARTELL

Louis H. Martell, president of the Martell Packings Co., Elyria, Ohio, died on January 31, 1919. Mr. Martell was born in Tusket, Nova Scotia, Canada, on February 26, 1864. He was educated in Mt. Clemens, Mich., serving a three-years' apprenticeship with the Michigan Central Railroad, Jackson, Mich. He was later employed by the Boston, Revere Beach and Lynn Railroad and also served as an engineer on coast-wise steamers.

He was also connected with W. B. Merrill & Co., Boston, and under his management the Pitt Manufacturing Co. was organized. In 1908 he became associated with the Metallic Packing & Manufacturing Co. Mr. Martell became a member of the Society in 1906.

STEPHEN PAUL HOSKINS

Stephen Paul Hoskins, 319 Infantry, A. E. F., was killed in action on November 2, 1918, in one of the battles of the Argonne Forest and lies buried near the little town of Imecourt.

Lieutenant Hoskins was born on May 22, 1891, in Erie, Pa. He received his education in the grade schools of Pennsylvania and West Virginia, later attending the West Virginia Wesleyan College and the West Virginia University. He was graduated from the latter in 1914 with the degree of B. S. in mechanical engineering. The year following his graduation he was assistant in mechanical drawing in the University, and later instructor in machine design and mechanical drawing.

LIEUT. STEPHEN P. HOSKINS

He left this position to become efficiency engineer with the research division of the Westinghouse Electric & Manufacturing Co., Pittsburg, Pa., where he remained until June, 1916. An attack of inflammatory rheumatism made it necessary for him to sever temporarily his business connections and upon his recovery he entered the service at Camp Lee, Petersburg, Va., in October, 1916. He was recommended for the Third Officers' Training Camp and just before leaving for France was graduated as second lieutenant. He was later promoted to first lieutenant for bravery on the field and just prior to his death was recommended for promotion to the grade of captain and for the Distinguished Service Cross.

Lieutenant Hoskins became a junior member of the Society in 1916.

HARRY DREW EGBERT

Harry Drew Egbert was born at Bay Head, N. J., on August 24, 1886, and died of pneumonia on March 23, 1919. He was educated in the Jersey City public schools and in the Newark Academy. He entered Columbia University in 1904 as a sophomore. The year previous to his entrance he spent with his father, Prof. J. C. Egbert of Columbia, in Rome, where the latter was serving as professor of classical literature in the American School of Classical Studies.

Mr. Egbert was graduated from Columbia University in 1907. He then entered the Schools of Applied Science and spent three years in study for the degree of mechanical engineer which he received in 1910. In the summer during his scientific study he attended the course in surveying at Camp Columbia and was an apprentice in different shops where he became familiar with the practical side of his profession.

After his graduation Mr. Egbert became a member of the office force of the Guaranty Construction Co. After two years he was asked to join the staff of the Research Corporation and in connection with this organization he became an expert on electrical precipitation and was the author of many articles on this subject.

He was a member of the Phi Beta Kappa and Sigma Xi societies. He became a junior member of our Society in 1915 and was secretary of the New York Section, the Executive Committee of which on April 9, 1919, adopted the following resolution:

Resolved, That there be entered upon the minutes the sincere regret of the Committee and their appreciation of his splendid achievements as an engineer and his untiring effort to at all times advance the interest of the Profession, the Society and this Committee.

CHARLES B. RICHARDS

Charles B. Richards, scientist and inventor, for 25 years Higgins Professor of Mechanical Engineering at Yale University and for the last nine years professor emeritus, died on April 20, 1919, in his eighty-sixth year. Professor Richards was a charter member of the Society, having served as manager 1880-1882 and as vice-president, 1888-1890. A more extended biographical sketch will be published in the June issue of MECHANICAL ENGINEERING.

CHARLES H. MANNING

Capt. Charles H. Manning, for many years prominent in engineering circles in New England, died at Manchester, N. H., on April 1, 1919, in his seventy-fifth year. Captain Manning became a member of the Society in 1884 and was elected to Honorary Membership in 1913, having served as manager 1892-1895 and as vice-president 1895-1897. In the June issue of MECHANICAL ENGINEERING a more extended account of Captain Manning's life and activities will appear.

PERSONALS

In these columns are inserted items concerning members of the Society and their professional activities. Members are always interested in the doings of their fellow-members, and the Society welcomes notes from members and concerning members for insertion in this section. All communications of personal notes should be addressed to the Secretary, and items should be received by May 15 in order to appear in the June issue.

CHANGES OF POSITION

WILLIAM A. BLACKBURN has severed his connections with the Bryant Manufacturing Company, Chicago, Ill., as works manager, and has assumed the position of general manager of the Gray Motor Company, Detroit, Mich.

F. W. CLEVELAND, formerly assistant superintendent of equipment, Pratt and Whitney Company, Hartford, Conn., has accepted a position with the Illinois Watch Company, Springfield, Ill., in the capacity of equipment engineer.

ARTHUR C. WHATLEY, formerly marine draftsman, Bethlehem Shipbuilding Corporation, Bethlehem, Pa., is now in the employ of the Union Oil Company of California, Los Angeles, Cal.

W. H. DIEFENDORF of Syracuse, N. Y., has resigned his position as chief engineer and director of the New Process Gear Corporation, and is now with the Weeks-Hoffman Company of the same city.

JOHN J. EASON has resigned his position as manager of the Havana Iron Works and the Havana Dry Dock Company at Havana, Cuba, and has accepted a position with the U. S. Shipping Board, Emergency Fleet Corporation, Ship Construction Division, Philadelphia, Pa.

LEWIS A. BELDING, who for the past two years has been assistant professor of mechanical engineering at Stevens Institute of Technology, Hoboken, N. J., is now associated with the Thomas A. Edison interests at Orange, N. J., in the power service division, as service engineer.

CHARLES EISLER, for about five years with the Westinghouse Lamp Company, Bloomfield, N. J., as chief designer and engineer in charge of the equipment, designing and development departments, has resigned and has become associated with the recently organized Save Electric Corporation, Brooklyn, N. Y., in the capacity of superintendent of the equipment, designing and development departments.

KENNETH LYDECKER, formerly engineer with the Standard Oil Company of New Jersey, has become associated with The White Company, Cleveland, Ohio.

ALFRED W. KIMMEL, until recently mechanical engineer, Airplane Engineering Department, Bureau of Aircraft Production, McCook Field, Dayton, Ohio, has assumed the duties of general manager of the newly opened eastern office of the Charles M. Kelso Company, Inc., in Utica, N. Y.

RALPH B. KENNARD has become affiliated with the engineering department of the New Jersey Zinc Company, Palmerton, Pa. He was until recently connected with the Niagara, Lockport and Ontario Power Company, Buffalo, N. Y., in the capacity of chief draftsman.

LOUIS W. SIPLEY, formerly with the Midvale Steel and Ordnance Company, has become affiliated with the Electric Storage Battery Company, of Philadelphia, Pa., in the capacity of sales engineer.

WILLIAM L. DEBAUFRE has resigned from the Naval Engineering Experiment Station, Annapolis, Md., and has assumed the duties of designing engineer with the Precision Instrument Company, Detroit, Mich.

J. W. BRUSSEL, formerly superintendent of the Wright-Martin Aircraft Corporation, Long Island City, has accepted a position as factory manager of the Dyneto Electric Corporation, Syracuse, N. Y.

Walter H. Hall has accepted the position of plant engineer with the Champion Ignition Company, Flint, Mich. He was formerly connected with the Remington Arms Union Metallic Company, Swanton, Vt., as works engineer.

E. D. Walen, until recently associate physicist, Bureau of Standards, Washington, D. C., has assumed the duties of manager of the Textile Research Company, Boston, Mass., which has recently been organized by textile manufacturers for the conduct of research or to have research conducted for them along textile lines.

William Stewart Ayars has left the employ of the U. S. Shipping Board where he had been senior performance engineer, Division of Ship Construction, Philadelphia, Pa., and has entered the employ of the Pusey and Jones Company, Wilmington, Del., as chief estimator.

Lloyd D. Gilbert has accepted the position of chief engineer with the Sandusky Cement Company, Cleveland, Ohio. He was formerly chief engineer and superintendent with the Southwestern Portland Cement Company at Victorville, Cal., and also engineered the El Paso plant for the same company.

I. Tornberg, formerly assistant chief draftsman, R. Hoe and Company, New York, has become associated with the Wood Newspaper Machinery Corporation, Plainfield, N. J., in the capacity of engineer.

ANNOUNCEMENTS

K. G. Walker has become affiliated with the Atlas Company, of Lincoln, N. J.

Capt. Philip F. Miller, Ordnance Department, U.S.A., has been discharged from the Army and has become connected with the New York sales office of the A. S. Cameron Steam Pump Works, New York.

Eugene E. Maher has resigned from the district sales managership of the Terry Steam Turbine Company, Hartford, Conn., and has opened offices in Chicago, Ill. He will handle sales and construction of lines of centrifugal, triplex and steam pumps, and engines.

Barzillai G. Worth, vice-president and general manager of Walter Kidde and Company, Inc., New York, has been elected treasurer of the Monmouth Chemical Company, which produces potassium chlorate electrolytically, using processes and apparatus developed under Mr. Worth's direction and whose manufacturing is technically supervised by Walter Kidde and Company, Inc. A contribution to the war was the development by this organization for the Monmouth Chemical Company of a special bromate free chlorate surpassing the German standard, which was adopted by the Ordnance Department to eliminate the causes for ammunition failures reported to Congress in the early stages of the war by Secretary Baker.

Reuben Hill, Major, Ordnance Department, U. S. A., has received his discharge from the service and has accepted the position of chief engineer with the Pratt and Whitney Company, Hartford, Conn.

George E. Harris, for the past year First Lieutenant, U.S.A., assigned to the Bureau of Aircraft Production, Finance Department, has become connected with the Hawkridge Brothers Company, Boston, Mass., in the capacity of director of sales. Mr. Harris has been engaged in the steel business, in both operating and selling ends, for the past 20 years.

A. L. Kershaw has accepted a position with the Electric Auto-Lite Corporation, of Toledo, Ohio.

A. B. Taggart, formerly secretary and treasurer of the Advance Machinery Company, has gone into business in Toledo, Ohio, under the firm name of Toledo Glue Appliance Company, as a designer and manufacturer of glue heaters. Mr. Taggart was connected with the Advance Machinery Company for about seven years, disposing of his interest there last July to enlist. His new company will specialize as consulting engineers in agglutinants and methods of preparing them for use.

Major C. E. Whipple has been honorably discharged from the U. S. Army and has returned to his duties as general manager and treasurer of the New York Central Iron Works Company, Hagerstown, Md.

W. H. Kniskern has become connected with the engineering division, nitrate products department, of the General Chemical Company, New York.

George L. Lubbert has resigned his position of chief operating engineer, Filtration Plant, Baltimore City Water Department, and is now engaged in the electrical and mechanical engineering and contracting business with office in Baltimore, Md.

F. J. Ryan, general manager of the American Metallurgical Corporation, Philadelphia, Pa., was elected to the position of vice-president and treasurer, also continuing as general manager.

T. W. Ransom, chief inspector for the Emergency Fleet Corporation, has resigned, and on April 1 resumed his own offices in San Francisco, as consulting engineer.

Henry M. Leps has assumed the position of general superintendent for the Kanawha Manufacturing Company, Charleston, W. Va.

Herbert M. Hill has accepted a position with the Paper Utilities Corporation, New York, in the capacity of mechanical engineer.

Carl Ehrmann has severed his connection as chief engineer of the Oklahoma Petroleum and Gasoline Company, Tulsa, Okla., and has opened offices as consulting engineer in the same city.

Dean E. Foster, Secretary of the recently organized Mid-Continent Section of the Society, on April 1 severed his connection with Cosden and Company to enter consulting practice with F. P. Peterson, under the firm name of Frank P. Peterson Company, Tulsa, Okla.

Thomas Chester has opened an office in St. Louis, Mo., in order to manage the St. Louis district office for the American Blower Company. He was until recently connected with the New York office of the company as special representative, handling the Navy business.

Lieut. F. C. Holmgren, who returned from France in February, has taken the management of the Philadelphia branch of the Trailmobile Company. Lieutenant Holmgren has been identified with the automobile and truck industry since 1905.

Clarence O. Hartman has become associated with the Atlas Portland Cement Company, Northampton, Pa. He was, until recently, connected with the Engineering Bureau of the U. S. Government at Washington, D. C.

B. J. Cline has assumed the position of factory manager of the Templar Motors Corporation, Cleveland, Ohio.

Captain Harvey S. Benson has left the Ordnance Department, U.S.A., and has assumed the duties of factory manager of the Caskey Dupree Manufacturing Company, of Marietta, Ohio.

Major Lefferts Hutton, M.C., son of the late Prof. Frederick R. Hutton, Past-President and Honorary Secretary of the Am. Soc. M.E., has been cited for exceptional energy and zeal in the performance of all duties as assistant division surgeon and for courage displayed under fire in the forward areas. This throughout the service of the division in Belgium and in France.

Leo Mayer, for nine years construction engineer for the Otis Elevator Company at New York and Cleveland, and more recently with the Bureau of Construction and Repair, Navy Department, has resigned his position with the Navy Department and has established himself as sales engineer with offices in Boston, Mass., specializing in conveying and material handling machinery. Mr. Mayer also represents the Standard Conveyor Company, of St. Paul, Minn.

John R. Battle has opened an office in Philadelphia, Pa., as consulting industrial oil and mechanical engineer. He was, until recently, mechanical engineer and Philadelphia manager of Swan and Finch Company, of New York.

Lieut. Wallace J. Cross, Engrs. U.S.A., has been discharged from service and has accepted the position of assistant mechanical engineer with the Watson Engineering Company, Cleveland, Ohio.

Major James Guthrie, U.S.A., Ordnance Engineering, has returned to Cleveland and reopened his consulting engineering office. Major Guthrie put aside his practice in order to enter active service at the beginning of the war, completing a staff assignment in Washington and serving eight months as engineering manager of the Michigan Ordnance District.

Lieut. Richard S. Austin, of Brooklyn, N. Y., a member of the 166th Aero Squadron, was cited by General Pershing for valor during the Argonne-Meuse offensive.

APPOINTMENTS

Harold J. Williams, First Lieutenant, Ordnance Department, U.S.A., who for the last 16 months has been attached to the Mobile Gun Carriage Section of the Artillery Division, Washington, D.C., has resigned his commission in the Ordnance Department to accept the appointment of engineer for the Beacon Falls Rubber Shoe Company, Beacon Falls, Conn., and associated interests. Prior to his entry into service, Mr. Williams was consulting and mechanical engineer, and was also on the teaching staff of Pratt Institute, Brooklyn, N. Y.

AUTHORS, ETC.

Miss Kate Gleason, the first woman to be elected a member of the Am. Soc. M.E., addressed the Rochester Engineering Society at its weekly meeting on March 17 at the Hotel Seneca. She described engineering features noted on her recent visit to the Orient.

Major W. B. Gregory has been appointed representative of the Louisiana Engineering Society at the conference of Engineering Societies to be held in Chicago, April 23 to 25.

LIBRARY NOTES AND BOOK REVIEWS

Aeronautical Engines. A Critical Survey of Current Practice with Special Reference to the Balancing of Inertia Forces. By Francis Jogn Kean. Second edition. Spon & Chamberlain, New York, 1918. Cloth, 5 x 8 in., 101 pp., 49 illus., 31 pl., $2.50.

This book consists of a course of ten lectures given during 1915 to men of the Royal Naval Air Service and the Royal Flying Corps, designers and engineering students.

The Design and Construction of Dams. Including Masonry, Earth, Rock-fill, Timber and Steel Structures, also the principal types of Movable Dams. By Edward Wegmann. Sixth edition, revised and enlarged; 1918 reprint revised. John Wiley & Sons, Inc., New York, 1918. Cloth, 9 x 12 in., 529 pp., 157 pl., 24 tables, $6.

The present volume is a reprint, with revisions, of the sixth (1911) of this well-known and popular treatise. A special feature of the book is the detailed information given concerning important dams in all parts of the world.

Compressed Air Plant. By Robert Peele. Third edition. John Wiley & Sons, Inc., New York. 1919. Cloth, 6 x 9 in., 485 pp., 246 illus., 54 tables, $4.25.

This edition has undergone a thorough revising, and a number of chapters have been rewritten and several have been expanded, while old material has been condensed or omitted. The volume describes current practice in the construction and operation of compressors and discusses the applications of compressed-air drilling, pumping and hauling, with special reference to mine service.

Cotton Facts. (Edition of October, 1918.) Compilation from Official and Reliable Sources of the Crops, Receipts, Exports, Stocks, Home and Foreign Consumption, Visible Supply, Prices, and Acreage of Cotton in the United States and Other Countries for a Series of Years. Also Cotton-Mill Statistics of the United States, Europe, India, etc., the Reports of Condition of Growing Cotton Crops, issued by the U. S. Department of Agriculture and the Cotton Acreage and Yield of each State and County in the South according to the U. S. Census. Edited by Carl Geller. Shepperson Publishing Co., New York, 1918. Cloth, 4 x 7 in., 240 pp., 1 por., $1.

This volume is the forty-third annual issue. In a book of pocket size, it presents the statistics needed by cotton merchants, manufacturers and growers, as indicated in the title.

Gasoline and Kerosene Carburetors. Construction—Installation—Adjustment. A simple, comprehensive Treatise for Practical Men, explaining all principles pertaining to Carburetors for all Types of Internal-Combustion Engines intended to operate on Liquid Fuels such as Gasoline, Kerosene, Benzol and Alcohol. By Victor W. Pagè. The Norman W. Henley Publishing Co., New York, 1919. Cloth, 5 x 8 in., 219 pp., 89 illus., $1.50.

A handbook for operators of internal-combustion engines. Explains in non-technical language the principles of carburetors, the usual modern types and the method of adjusting and repairing them.

Graphic Charts for the Business Man. By Stephen Gilman. La Salle Extension University, Chicago, 1918. Paper, 6 x 9 in., 62 pp., 56 illus.

A pamphlet showing the value of charts in presenting statistical data, and describing some of the varieties used in business.

Hendrick's Commercial Register of the United States for Buyers and Sellers. With which has been incorporated The Assistant Buyer. Especially devoted to the Interests of the Electrical, Engineering, Hardware, Iron, Mechanical, Mill, Mining, Quarrying, Chemical, Railroad, Steel, Architectural, Contracting and kindred Industries. A complete and reliable annual Register of Producers, Manufacturers, Dealers and Consumers connected with the aforesaid Industries. S. E. Hendricks Co., Inc., New York, (copyright 1918). Cloth, 8 x 10 in., 2381 pp. $10.

This register of producers, manufacturers, dealers and consumers connected with the engineering and industrial activities of the country has been carefully revised and corrected. The firms included are listed alphabetically and also carefully classified. A section containing trade names and brands, with the names of manufacturers, forming a convenient ready reference list for purchasers, is a distinctive feature.

Mill and Cyanide Handbook. Comprising Tables, Formulæ, Flow-sheets, and Report Forms, compiled and arranged for the use of Metallurgists, Mill-men and Cyanide Operators. By W. A. Allen. J. B. Lippincott Co., Philadelphia, 1918. Cloth, 4 x 7 in., 128 pp. $2.

The author has tabulated the physical, chemical and mechanical data needed by mill-men, in a volume of convenient size, well indexed. A glossary of mill and cyanide terms is included.

Modern Shipbuilding Terms Defined and Illustrated. Including a Series of Photographs showing the Progressive Steps of Construction, together with an Appendix on Electric Welding. By F. Forrest Pease. Lippincott Co., Philadelphia, (copyright 1918). Cloth, 5 x 8 in., 143 pp., 68 pl. $2.

This work contains a glossary of the more common words and phrases used in building a steel ship; a list of shipyard trades and the duties performed by each; a series of instruction charts on electric welding; a list of symbols used on plans and parts; a description of the Isherwood system of shipbuilding; directions for the use of acetylene, hydrogen and oxygen for cutting and welding; and a select list of books on ship construction and equipment. The plates illustrate the construction of a ship by the usual methods, the construction of the "fabricated" ship, and the tools, machines and installations.

Simplified Navigation for Ships and Aircraft. A Text Book based upon the Saint Hilaire Method. By Charles Lane Poor. The Century Co., New York, 1918. Cloth, 126 pp., 10 illus., 7 charts, 4 tab. $1.50.

This work is an attempt to explain in non-technical language and without the use of complicated mathematics the principles which form the basis of modern methods of navigation. Particular attention is given to aerial navigation.

A Study of Engineering Education. Prepared for the Joint Committee on Engineering Education of the National Engineering Societies. By Charles Riborg Mann. (Carnegie Foundation for the Advancement of Teaching, Bulletin number 11). New York, 1918. Paper, 8 x 10 in., 139 pp.

The purpose of this report is to examine the fundamental question of the right methods of teaching and of the preparation of young men for the engineering professions. In the light of the fifty years of experience of the engineering colleges of the United States, an effort has been made to suggest the pedagogic basis of the course of study intended to prepare young men for the work demanded of the engineer to-day, without losing sight of the point of view of the teacher, the engineer, the manufacturer and the employer. A limited number of typical schools were visited and studied by Professor Mann and the views of the whole engineering profession throughout the country were ascertained in the course of the investigation. It is the hope of the Committee that the report will awaken wide interest because of its applicability, and that its influence on engineering education will be beneficial.

The Silk Directory. Davison's Silk Trade. Office Edition. A Directory of the Silk Manufacturers of the United States and Canada, including Silk Dyers, Finishers and Printers; Manufacturers' Agents; City Offices and Salesrooms of Silk Mills; Dealers in Raw, Thrown, Spun and Artificial Silk; Waste; Cotton, Tinsel and Worsted Yarns; Silk Jobbers and Retailers and a Classified Directory of All Manufacturers of Silk Goods. Twenty-third annual edition. Davison Publishing Co., New York. (Copyright, 1918.) Cloth, 8 x 6 in., 778 pp. $3.50.

The directory includes dyers, finishers, printers, manufacturers' agents, city offices and salesrooms of mills, dealers, jobbers, retailers and manufacturers. These are given in lists classified primarily by occupation and secondarily by location. The lists have been carefully revised and enlarged by the addition of new establishments.

SUCCESS IN THE SMALL SHOP. By John H. Van Deventer. Second edition. Published by American Machinist. (McGraw-Hill Book Co., Inc., sole selling agents), New York, 1918. ¼ cloth, 9 x 11 in., 137 pp., illus. $1.75.

A series of articles, 50 in number, dealing with the problems of small machine shops, that appeared originally in the *American Machinist*. The articles discuss economic conditions, management, equipment, methods, etc., and are intended to be of practical help to owners and workmen.

HANDBOOK OF CHEMISTRY AND PHYSICS. Compiled by Charles D. Hodgman, assisted by Melville F. Coolbaugh and Cornelius E. Senseman. The Chemical Rubber Co., Cleveland, Ohio, 1918. Flexible cloth, 4 x 7 in., 557 pp., $2.50.

This compilation is intended to present in one volume of convenient size a comparatively comprehensive reference book for the use of chemists and physicists. The seventh edition has been enlarged by one hundred pages, which contain a revision of a table of the physical constants of organic compounds. This table now includes about two thousand substances. Various minor additions and corrections have been made throughout the work.

HEATON'S ANNUAL. 15th Year, 1919. Published by Heaton's Agency, Toronto, Canada. Cloth, 5 x 7 in., 512 pp. (including advertisements), $1.50.

A handbook of condensed commercial and industrial information on Canada. Describes the natural and commercial resources of the provinces, and industrial opportunities in the towns and cities. Much general information of use to visitors and business men is included.

A MANUEL OF CHEMICAL NOMOGRAPHY. By Horace G. Deming. The University Press, Champaign, Ill., 1918. In two parts, text and tables, $1.25.

The Noman (part one) is a nomographic reckoner, devised by the author for the graphic solution of various arithmetical problems. Multiplication, division, powers, roots and logarithms can be treated by the eighteen charts, with an average error of one part in four or five thousand.

The manual describes the method of using the Noman and gives specific examples of its application to the solution of chemical problems and indicates the kinds of calculations in which it is most useful.

MODEL MAKING. Including Workshop Practice, Design and Construction of Models. A Practical Treatise for the Amateur and Professional Mechanic. Gives Instructions on the Various Processes and Operations Involved in Model Making and the Actual Construction of numerous Models, including Steam Engines, Speed Boats, Guns, Locomotives, Cranes, etc. Lathe Work, Pattern Work, Electroplating, Soft and Hard Soldering, Grinding, Drilling, etc., are also included. Edited by Raymond Francis Yates. The Norman W. Henley Publishing Co., New York, 1919. Cloth, 6 x 9 in., 390 pp., 303 illus., 1 pl., $3.

The author hopes that his book will promote interest in model engineering in this country, and will also give a correct impression of its value as a recreation.

NINETEENTH YEAR BOOK. Of the Rubber Association of America, Inc., New York, 1918. Paper, 6 x 9 in., 119 pp.

Contains list of members, constitution and annual report for 1918.

PUBLIC UTILITY RATE FIXING. Comments on Current Problems Pertaining to Public Utilities and to Rate Fixing. By C. E. Grunsky. Technical Publishing Co., San Francisco, 1918. Cloth, 6 x 9 in., 169 pp., 5 charts, 2 pl., $2.50.

A reprint of a number of articles originally contributed to the *Journal of Electricity*, written in the hope that they may prove helpful in determining fair rates for the output of public utilities and in prescribing methods of procedure when rates are to be fixed; and that they may assist in the solution of some of the economic problems which arise in the readjustment to peace conditions.

RADIATION, LIGHT AND ILLUMINATION. By Charles Proteus Steinmetz. Compiled and edited by Joseph LeRoy Hayden. Third edition. McGraw-Hill Book Co., Inc., New York, 1918. Cloth, 6 x 9 in., 305 pp., 127 illus., 1 pl., 14 tables, $3.

A series of twelve experimental lectures, most of which were delivered in 1908-1909, with the exception of two lectures on Light Flux and Distribution, and Light Intensity and Illumination. The treatment is non-mathematical and discusses the subjects in plain language. This edition is apparently a reprint of the preceding ones.

THE SHIPBUILDING INDUSTRY. By Roy Willmarth Kelly and Frederick J. Allen, with an introduction by Charles M. Schwab. Houghton Mifflin Co., Boston and New York, 1918. Cloth, 6 x 8 in., 303 pp., 64 pl. $3.

The primary purpose of this volume, as stated by the authors, is to describe and interpret for the general public, as well as for those employed in the shipyards, our war emergency shipping program and the task of the shipbuilders. It is also hoped that the book will help those who wish to prepare themselves for executive positions and those considering shipbuilding or naval architecture as a possible life calling.

STEAM ENGINE TROUBLES. A Practical Treatise for the Engineer, telling how to locate and remedy troubles with a Steam Engine. Cylinders, Valves, Pistons, Frames, Pillow Blocks and other Bearings, Connecting Rods, Wristplates, Dashpots, Reachrods, Valve Gears, Governors, Piping, Throttle and Emergency Valves, Safety Stops, Flywheels, Oilers, etc., are all treated. By H. Hamkens. The Norman W. Henley Publishing Co., New York, 1919. Cloth, 5 x 8 in., 284 pp., 276 illus., $2.50.

A simple account of the troubles which may arise in steam-engine operation, the causes and the proper remedies. Intended for the power-plant engineer. Based on a series of articles published in *Power*.

THE ENGINEER AS A CITIZEN

(*Continued from page 451*)

engineers have placed a stamp more marked than any other group of men. Among the every day questions in legislation and administration are many engineering problems. The engineer's knowledge is therefore needed in the public affairs of today, and the engineering profession must recognize the duty of making available to Society its peculiar training and experience.

Public activity, to be effective, must be carried on by groups rather than by individuals. A prerequisite of any worth-while public profession or activity, therefore, is the organization of the whole engineering profession in such a manner that it may be mobilized in city, state and nation for the purpose of giving representative opinion, appointing representative individual engineers or committees and securing united action.

Even in professional activities better organization of the profession is desirable because there no longer exist clear lines of demarkation between the spheres of interest of individual groups of engineers and because many activities, like standardization and research, can be carried on effectively only if undertaken jointly. There are in this country several hundred engineering societies having in common many aims and purposes and duplicating efforts to a large degree.

Organization and coördination of efforts is not possible without previous crystallization of aims and purposes of individual societies. Four large national engineering societies have appointed special committees for the purpose of securing such crystallization.

This meeting, attended by members of engineering and scientific societies having a total metropolitan membership of about 15,000, feels strongly that more coöperation among all groups of engineers and among all existing engineering societies is essential. It is therefore—

Resolved, that all engineering societies of this country, not yet having committees on development, be asked to appoint such committees with instructions to undertake a survey of the aims and purposes of their respective associations and to coöperate with corresponding committees of other engineering and similar societies; and it is further

Resolved, that a copy of these resolutions be sent to every engineering society in this country.

Following the passing of this resolution, the chair appointed Mr. Castle secretary of the meeting and instructed him to carry out the order of the resolution.

Before the meeting adjourned Spencer Miller offered the following resolution, which was unanimously adopted:

Resolved, that the representatives of the local sections of the various engineering bodies here present tonight recommend to their bodies that these bodies shall send a delegate to a common engineering conference for the purpose of discussing, formulating and reporting back to their respective bodies a Code for Professional Conduct, with a view of its adoption by all the engineering bodies involved as the common code for the engineering profession.